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UNCLASSIFIED   AFGL-TR-81-0261   NL

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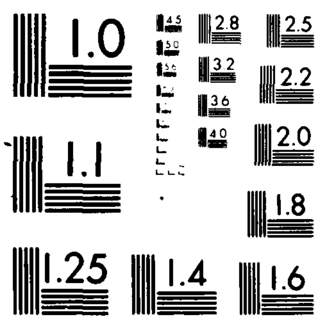

MICROCOPY RESOLUTION TEST CHART

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DEVELOPMENT AND APPLICATIONS OF TECHNIQUES TO PROCESS HYDROMETEOR DISTRIBUTION DATA

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FINAL REPORT FOR PERIOD 1 MAY 1978 TO 31 JULY 1981

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
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This report summarizes the mathematical procedures used on a variety of standard and non-standard cloud physics data. It includes the complete descriptions and operating instructions for all programs developed under this contract.

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The following abbreviations are used throughout this report.

AFGL	Air Force Cambridge Research Laboratories
LYC	Convective Cloud Physics Branch of the Air Force Geophysics Laboratory
PRECIP PROBE	Precipitation Probe

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1. Introduction

During the period of May 1978 to July 1981 DPSI was under contract (F19628-78-C-0131) to the Convective Cloud Physics Branch (LYC), Meterology Division of the Air Force Geophysics Laboratory (AFGL). LYC is the Air Force office abbreviation for Cloud Physics Branch and will be used interchangeably throughout this report. The purpose of this contract was to develop and apply mathematical procedures to a variety of standard and non-standard cloud physics research data.

Work, under this latest contract, was performed on two distinct computer systems. The AFGL inhouse Cyber 74 Computer Systems (Control Data Corp.) and two DEC (Digital Equipment Corp.) PDP-8/E's. The major delineations of this report is along those lines. Chapter 2 describes CDC Cyber 74 programming while chapters 3 and 4 details real-time programming for the PDP-8/E installed on an AFGL operated MC-130E instrumented aircraft; and an in-house LYC PDP-8/E for testing of flight programming and post flight analysis.

The work performed under this contract has been submitted, in detail, in a set of 39 monthly reports. This document will summarize changes to existing programs; in addition, new programs and procedures will be fully described in this document. A complete set of updated documentation and operating instructions for each program is included.

2. CYBER 74 PROGRAMMING

LYC is a support facility to the USAF in the area of cloud physics research. Practical applications, rather than pure research are emphasized as the mission of the branch. At present these practical applications are in the following areas:

- aircraft icing rates
- melting layer research
- AFFTC spray test
- radar correlation
- Pasarelli spiral

The following chapter describes the contributions that DPSI has made in the above areas during the length of this contract.

Specific programs are listed under each general application. For every program the inherent mathematical modeling will be fully described or referenced. In addition a sample output description will be included.

Full operating instructions are presented for each program. The user of this information should be familiar with the contents of the "AFGL USER'S GUIDE". That document describes most of the conventions that must be complied with in order to run jobs on AFGL CYBER systems. Although the user's guide is a much simplified version of the set of CDC cyber manuals it gives enough information for the running of simple jobs. This knowledge plus the detailed operating instructions presented in this document are quite sufficient for the proper running of the programs.

2. CYBER 74 Programming (cont'd)

DPSI maintains all CYBER programming on a disk pack (LYCPFI) owned by the computer center (SOD). In the succeeding documentation DPSI uses the convention of attaching, in the instructions, the word BIN to the program name (LYCPFI file name) when using the system command "ATTACH" to make the compiled program local to a user job.

```
ex.  ATTACH,LGO,PLTEXTRACTBIN,ID=GLASS,MR=1.
     LGO.
```

The binary of program PLTEXTRACT is made local to the job as a file named LGO. Repetition of the name tells the system to load it and begin execution. DPSI maintains several binaries on the shared system (ID=GLASS) using this convention. However not all programs are so saved. The computer center does not allow files to be stored on the shared disk system without their continued usage. For this reason DPSI maintains only the most frequently used binaries on the disk. If the user wants a program not currently on the shared system (determined by use of the "audit" command) there are two options. INTERCOM can be used to attach the program. This will compile and save the binary on the shared system as above. Or, the control deck can be altered by placing a "PK" parameter on the first card and replacing the original attach with the following cards:

```
ex.  PAUSE.  PLS MOUNT DISK LYCPFI.
     MOUNT,VSN=LYCPFI,SN=LYCPFI.
     ATTACH,P,PLTEXTRACT,ID=LALLY,SN=LYCPFI.
     FTN,I=P,PL=999999.
     LGO.
```

2. CYBER 74 Programming (cont'd)

In this example the compilation is actually done during the job. In the succeeding documentation the single attach convention will always be used. It is left to the user to determine if the particular program is or is not currently on the shared system.

2.1 PMS-1D processing

The PMS-1D particle sizing system consists of three different probes that record particle counts in overlapping size ranges. The Axial Scattering Probe detects particles in the 2-30μ range. The 20-300μ particles are measured with the cloud probe. The Precip (or Precipitation) Probe is used for particles in the 200-4500μ range. Actual size ranges for the probes in each aircraft are shown in the following chart.

	C130	LEAR
Axial Scatter	2-30μ	2-30μ
Cloud	20-300μ	20-300μ
Precipitation	300-4500μ	200-3000μ

The Axial Scattering Probe is considerably different than the other two. It measures optical forward scattering from small particles in a constant size sampling volume. Dual photodiode detectors are used to verify that the particles are within the sampling volume. There is pulse height detection circuitry to classify the particles into fifteen size categories. The size classes are then read out by the data acquisition system at one second intervals.

This probe is specifically designed for water particles only. Since the scattering function of ice crystals is poorly understood, the probe is used only to indicate relative numbers but is not normally relied upon for determining mass of ice crystals.

The Cloud and Precip Probes utilize a laser beam condensed and mirrored to a zoom lens which distributes light to a row

2.1 PMS-1D processing (cont'd)

of diode sensors; the cloud probe has 22 sensors and the precip 24. As the aircraft flies, particles appear between the zoom lens and the sensors, interrupting the light. A shadow is cast, shutting off some of the diode sensors. The device is read when a diode is turned off, and the sampling is continued as any diode state changes until all diodes are back on. At the conclusion, then, a particle of known diode length has been counted; the output consists of the count of particles seen for lengths of one to fifteen diodes for each second. As an example, if a particle traces the following states in the diodes (0 = diode on; X = diode off)

```
0000000000000000000000
0000000XX0000000000000
000000XX00000000000000
0000XXX000000000000000
0000000000000000000000
```

Figure 2.1: Particle trace through PMS-1D system

the result would be 1 particle of diode length 5. The "5" results from the maximum different number of diodes turned off from start to finish of the sampling (all within a fraction of a second).

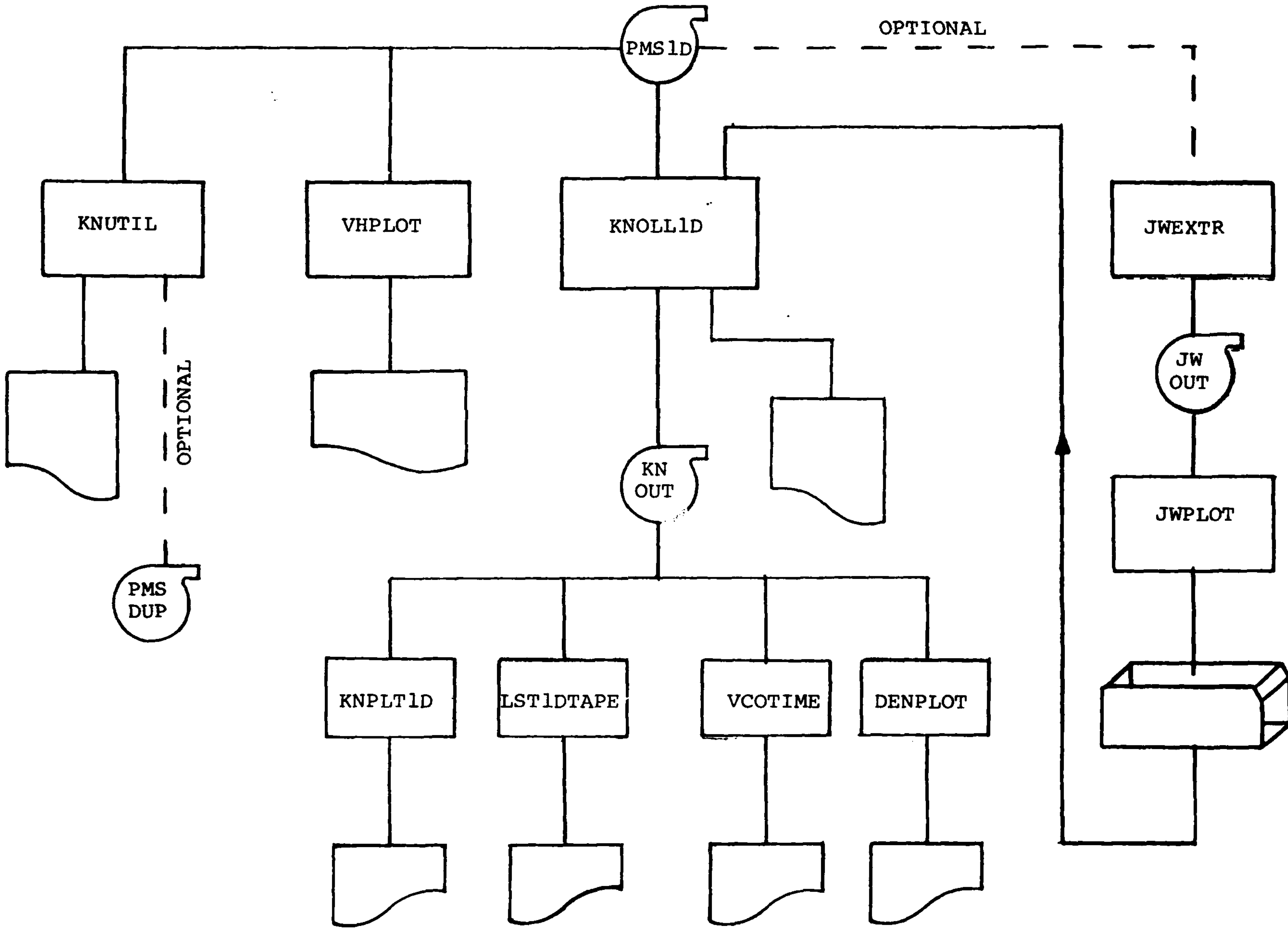
On board the MC-130 aircraft, a Kennedy 7-track recorder records the PMS-1D particle counts. In addition there are a number of data sensors aboard the aircraft. These are fed directly to voltage controlled oscillators (VCO's) and are hard wired to this output stream by analog to digital converters. These

2.1 PMS-1D processing (cont'd)

sensors contain environmental information of pressure, temperature and dewpoint, as well as, information of heading and speed.

Figure 2.2 is a graphic illustration of the processing options available for this data. This section describes these programs in detail.

Figure 2.2: PMS-1D Processing Program Flow



2.1.1 Program KNOLL1D

The one dimensional PMS measuring devices along with the aircraft VCO's is written on the Kennedy recorder in real time. It is this Kennedy tape which is delivered to LYC for post processing. The first of these post processing programs, and indeed the most extensive, is KNOLL1D. Section 2.1.1.1 through 2.1.1.15 explain in detail the calculations and techniques of KNOLL1D; the operating instructions and sample output will be found in sections 2.1.1.6 and 2.1.1.7.

A complete familiarization with KNOLL1D is mandatory for all users. This program is actually the "workhorse" of LYC, and since the nature of all the work is research, DPSI is often required to make alterations in order to examine changes in the scientist's theories. Of course, modifications are also required from time to time because of sensor malfunctions on the aircraft.

2.1.1.1 Data unpacking and reformatting

The data record on the Kennedy recorder consists of 256 words of 24 bits per word (see appendix 2). When read into the CDC 6600, which has a 60 bit word length, this record becomes 103 words. It must be converted back to 256 words so that each word can be processed as a separate entity. Each 24 bit word consists of four 6 bit groups; the real information on each of these 6 bit groups is contained in the rightmost 4 bits. That is, of the 24 bits per word, only 16 are pertinent.

A COMPASS subroutine unpacks these values from the 103 read-in words to the 256 binary entities. This is done in three steps: firstly, the 24 bits for a word are separated out; secondly, the 16 bits of concern are isolated into 4 groups of 4 bits each; and thirdly, these bits are multiplied by the appropriate power of ten and added to form a single binary result.

An example will explain this technique

24 bit word (2869)	110010	111000	110110	111001
mask out 2 leading bits in each character	001111	001111	001111	001111
resultant	000010	001000	000110	001001
	D	C	B	A

2.1.1.1 Data unpacking and reformatting (cont'd)

integer value of:

$$
\begin{aligned}
A \times 10^0 &= 9 \times 1 &&= 9 \\
B \times 10^1 &= 6 \times 10 &&= 60 \\
C \times 10^2 &= 8 \times 100 &&= 800 \\
D \times 10^3 &= 2 \times 1000 &&= 2000
\end{aligned}
$$

the integer equivalent of
the 24 bit word = A+B+C+D = 2869

2.1.1.2 Particle Typing

Liquid water content is heavily dependent upon the type of particle seen by the PMS-1D device. This can be seen by considering the resultant mass when a particle of fixed diameter is snow rather than rain.

The particle type is determined manually via input cards. The particle type selected will control the crystal size and equivalent melted diameter equations used throughout the program. The next sections show these calculations in detail.

Manual particle typing requires the following information to be input:

(a) time interval that (b) and (c), below are in effect
(b) particle type for Cloud Probe
(c) particle type for Precip Probe

There is a maximum of 15 such specifications; each specification is called a pass, and may be thought of as a pass of the aircraft in a given Cloud/Precip medium. It should be noted that the cloud (see b, above) and precip probes (see c, above) may contain different types during the same pass. Appendix 3 lists all the available input particle type codes.

As previously discussed, the Scatter Probe works differently than the Cloud and Precip Probes. Essentially the probe is accurate for water droplets only and not ice crystals. It is for this reason that the program usually processes the scatter probe as rain.

2.1.1.3 Equivalent melted diameter calculation

The equivalent melted diameter calculated for each channel of the Cloud and Precip Probe is a three step procedure. The first step, channel number adjustment, is a function of particle type and channel number. The second step, crystal size determination, is a function of probe only. Finally, the equivalent melted diameter is a function of particle type, probe and crystal size. The complete procedure is shown in the following.

Step 1. Calculate adjusted channel number for each channel

$$N' = m_{1j}N + b_{1j} \qquad \text{for } N \leq BN_j$$

and

$$N' = m_{2j}N + b_{2j} \qquad \text{for } N > BN_j$$

where

N' = adjusted channel number
N = channel number
j = particle type code
BN = channel number breakpoint
b = intercept
m = slope

Step 2. Determine crystal size of each channel for each probe

$$CRSZ_N = Wd_p \cdot N'$$

where

$CRSZ$ = crystal size (mm)
Wd_p = probe diode width (mm)
N' = adjusted channel number

2.1.1.3 Equivalent melted diameter calculation (cont'd)

Step 3. Calculate equivalent melted diameter of each channel for each probe

$$D = c_{1j} \cdot CRSZ^{e_{1j}} \qquad \text{for } CRSZ \leq BC_j$$

and

$$D = c_{2j} \cdot CRSZ^{e_{2j}} \qquad \text{for } CRSZ > BC_j$$

where

D = equivalent melted diameter (mm)
CRSZ = crystal size (mm)
j = particle type code
c = coefficient
e = exponent

Note that steps 1 and 3 actually allow for two equations. The equation chosen is dependent upon the channel number (in step 1) or the crystal size (in step 3). Refer to appendix 4 for all the coefficients and exponents used in these calculations.

2.1.1.4 VCO calculation

The VCO's calculated by program KNOLL1D may be classified in two categories: standard and special. The standard VCO results are calculated using a quadratic equation with the appropriate calibration coefficients in order to convert from the measured quantities to engineering units. The special VCO's are initially calculated using the same equation but undergo additional calculations.

Note that the coefficients generally consist of a slope and intercept only, i.e. linear equation. Although the program can use a quadratic, most of the current calibrations have a higher order coefficient of zero. All the equations are shown as follows:

Standard VCO's

(including: dewpoint, true airspeed, two pressure devices, EWER and magnetic heading)

$$VCO = c_{0i} + c_{1i} \cdot x + c_{2i} \cdot x^2$$

where:

x = VCO counts
i = VCO channel
c_0 = intercept
c_1 = slope
c_2 = second-order coefficient

2.1.1.4 VCO calculation (cont'd)

Special VCO's
(including: height, true temperature, velocity, LWC-JW, ΔP, potential temperature, dewpoint, saturation vapor, vapor, and relative humidity)

1. Height (meters)

$$Ht = 44307.69 - 11872.42(P)^{0.190284}$$

where: P = pressure (mb) calculated from the selected VCO

2. Delta pressure (mb)

This initially uses the standard VCO equation to calculate IAS (indicated airspeed). IAS is then used in the following equation

$$\Delta P = (1.865x10^{-3}(IAS)-6.0149x10^{-2})(IAS)+3.96965$$

3. Mach number squared

This is a function of pressure and delta pressure, and is necessary for the temperature and velocity equations

$$MCHSQ = 5\cdot\left\{ \left(1 + \frac{\Delta P}{P}\right)^{2/7} - 1\right\}$$

where:

ΔP = pressure gradient (mb)
P = pressure (mb)
P is calculated from the standard VCO
ΔP is calculated from IAS VCO (see 6)

4. Temperature (°C)

There are three different methods to calculate tempera-

2.1.1.4 VCO calculation (cont'd)

ture. Although only one method uses the VCO, for uniformity, all three will be shown here. The actual method used within the program is a user option.

A. VCO method

This initially uses the standard VCO equation getting TTC. Then TTC is substituted in the following:

$$TEMP = (TTC + 273.16)/(1 + 0.1992 \cdot MCHSQ)$$

where:

TEMP = temperature (°K)
MCHSQ = mach number squared
TTC = VCO temp (°C)

B. Standard atmosphere model

This technique calculates temperature as a function of pressure.

$$TEMP = 76.88288 \cdot PRES^{0.190824}$$

where:

TEMP = temperature (°K)
PRES = pressure (mb)

C. Radiosonde temperature profile

This method allows a temperature-pressure table

2.1.1.4 VCO calculation (cont'd)

(maximum 20 levels) to be read as part of the input deck. After the exact pressure has been calculated, the temperature is determined by interpolation of the table.

All three methods calculate temperature in degrees Kelvin. A final step is required to convert to Celsius.

$$T(°C) = TEMP(°K) - 273.16°$$

5. Velocity (meters/second)

The velocity is calculated as a function of pressure, pressure gradient, and temperature.

$$VEL = \left\{\sqrt{1516.4(TEMP)(MCHSQ)} + 3\sqrt{\frac{TEMP}{PRES}}\right\}\{0.5144\}$$

where:

VEL = velocity (m/s)
TEMP = temperature (°K)
PRES = pressure (mb)
MCHSQ = mach number squared

6. Liquid water content - Johnson-Williams (LWC-JW)

LWC-JW is initially calculated using the standard VCO equation to solve for LWC. The LWC is then normalized to adjust for airspeed using...

$$LWC\text{-}JW = LWC \cdot \frac{200}{VEL}$$

2.1.1.4 VCO calculation (cont'd)

where:

LWC = liquid water content from standard VCO
VEL = velocity (knots)

KNOLL1D optionally inputs a set of JW-height profiles for making an additional adjustment to the calculated values. A description of this adjustment routine can be found in section 2.1.7 for program JWPLOT.

7. Meteorological parameters

Additional meteorological parameters are calculated from the previously determined VCO's they are listed below.

POTENTIAL TEMPERATURE (K) =

$$(T+273)*(\frac{1000}{P})^{.2857}$$

*DEWPOINT (C) =

$$9.84*10^{-4}*D^2+1.1305*D-0.012$$

SATURATED VAPOR PRESSURE (Mb) =

$$6.11*EXP\ 9.05*L(\frac{1}{273}) - \frac{1}{T+273})$$

* USED WHEN FROSTPOINT/DEWPOINT REGISTERS FROSTPOINT (VALUES LESS THAN ZERO).

2.1.1.4 VCO calculation (cont'd)

VAPOR PRESSURE (Mb) =

$$6.11*EXP\left(9.05*L\left(\frac{1}{273} - \frac{1}{DEWPOINT+273}\right)\right)$$

RELATIVE HUMIDITY (%) =

$$100*\frac{VAPOR\ PRESSURE}{SATURATED\ VAPOR\ PRESSURE}$$

L = -.586 * T + 597

T = TRUE TEMPERATURE (C)

P = PRESSURE (Mb)

D = DEWPOINT/FROSTPOINT PARAMETERS

We now turn our attention to the calibration to be used for the processing. Past experience has shown that the default coefficients (coefficients are omitted) used within the program should be 0.0, 1.0, and 0.0 i.e. slope equal to one, and the intercept and high order coefficient equal to zero. These default coefficients are replaced by the latest calibration coefficients which are entered as part of the VCO input data file. There are two advantages with this technique; the program does not have to be recompiled whenever there is a calibration change, and the VCO output may be adjusted or corrected by simply changing a coefficient in the file or temporarily through the input deck.

2.1.1.5 Sampling volume determination

The sampling volume is a fundamental calculation which must be performed before the particle number density may be determined. This volume is basically the "amount" of air per second a given probe is exposed to, while counting particles. Basically, the volume is the product of cross-sectional area (CSA) times distance, where the cross-sectional area is a function of probe. The CSA is defined as the product of the effective aperture width (EAW) and the depth of field (DOF) where the DOF and EAW are functions of channel number or class size. Figure 2.3 shows a pictorial representation of the sampling volume.

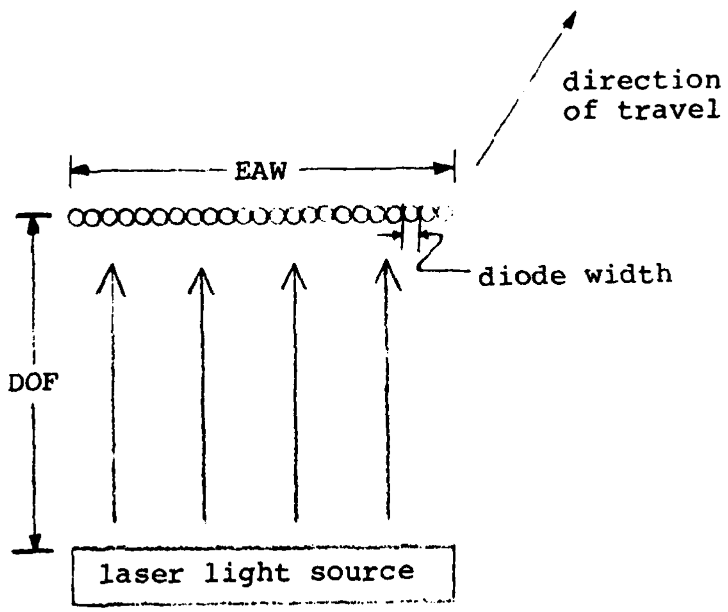


Figure 2.3: A pictorial representation of sampling volume

2.1.1.5 Sampling volume determination (cont'd)

The calculation for each probe is shown below.

1. Precip Probe

$$VOL = CSA \cdot DIST$$

where:

CSA = cross sectional area

DIST = distance travelled in one second

and: $CSA = DOF \cdot EAW$

where:

DOF = depth of field (constant .264 M)

EAW = effective aperture width

and: $EAW = W_d(23-N)$

where:

W_d = diode width (constant $300\mu = 3.10^{-4}$M)

N = channel number

this: $VOL = (.264)3 \cdot 10^{-4}(23-N) \cdot DIST$

or: $VOL = 7.92 \cdot 10^{-5}(23-N) \cdot DIST$

2. Cloud Probe

$$VOL = CSA \cdot DIST$$

where: CSA and DIST have been previously defined ($CSA = DOF \cdot EAW$)

2.1.1.5 Sampling volume determination (cont'd)

now: DOF = the minimum of $\{6.1, L\} \cdot 10^{-2}$ M

where: $L = 0.095N^2$

and: $EAW = W_d(21-N)$

where: W_d = diode width (constant $20\mu = 2 \cdot 10^{-5}$ M

thus: $VOL = 2.0 \cdot 10^{-7}(21-N)(\min\{6.1, .095N^2\})DIST$

3. Scatter probe

$$VOL = CSA \cdot DIST$$

where: CSA = cross sectional area (a calibrated constant-latest $4.59 \cdot 10^{-7} M^2$)

thus: $VOL = 4.59 \cdot 10^{-7}(DIST)$

The distance (DIST) for the three equations is calculated quite simply.

$$DIST = vt$$

where: v = aircraft velocity

t = time interval

The desired unit for distance is meters, so using velocity in meters/second, with a time interval of one second the equation reduces to

2.1.1.5 Sampling volume determination (cont'd)

$$DIST = [v(m/sec)] \cdot [1 (sec)]$$
$$DIST = v, \text{ with } v \text{ in units of m/sec}$$

This simplifies the volume equations to

$$VOL(PRECIP) = 7.92 \cdot 10^{-5}(23-N)v$$
$$VOL(CLOUD) = 2.0 \cdot 10^{-7}(21-N)(\min\{6.1, .095N^2\})v$$
$$VOL(SCATTER) = 4.59 \cdot 10^{-7}(v)$$

with the volume in units of cubic meters.

2.1.1.6 Barwidth approximation

The width of each channel, or class size, (commonly referred to as barwidth) is unfortunately not constant for the cloud or precip probes. It is however, constant (2μ) for the scatter probe.

The barwidth of any cloud or precip channel may be approximated as one-half-the difference between the adjacent channel center diameters. Algebraically this becomes

$$BW_N = \tfrac{1}{2}(D_{N+1} - D_{N-1}) \text{ for } 2 \leq N \leq 14$$

where: BW_N = barwidth of channel N
D_N = center diameter of channel N

The special cases are for class 1 and class 15.

$$BW_1 = D_2 - D_1 \qquad \text{for } N = 1$$

and

$$BW_{15} = D_{15} - D_{14} \qquad \text{for } N = 15$$

Using the barwidth and center diameter for any channel, the upper and lower limits of the channel can be derived using

$$LL_N = D_N - \tfrac{1}{2}\, BW_N$$

where: LL_N = lower limit of channel N

and $UL_N = D_N + \tfrac{1}{2}\, BW_N$

where: UL_N = upper limit of channel N.

2.1.1.6 Barwidth approximation (cont'd)

From these equations it can also be seen that

$$BW_N = UL_N - LL_N$$

The significance of these equations in terms of the 1D Particle Measuring System may be stated as follows: any particle, whose projected length is greater than or equal to a particular channel lower limit and less than or equal to a particular channel upper limit (that is, it is within a diameter class boundary), will be counted as a particle whose length is the center diameter of that particular channel.

2.1.1.7 Particle number density calculation

The particle number density is the fundamental variable in the liquid water content and radar reflectivity equation. KNOLL1D calculates these densities, for each probe and each class size, once per second. The number density is then averaged over a specified interval. Before the densities are output, however, they should be normalized.

This normalization is suggested because of the changing class size. As the channel number increases, the center diameter, of course, increases. However, a more important consequence is that the channel width (barwidth) also increases. This implies that it is really not quite correct to compare densities of different channels within the spectra. To alleviate this problem the number densities of each class are normalized, i.e. divided by their barwidth. It should be noted, however, the normalized density is only used as a means of comparison (i.e. plotting). Whenever the density is used in a calculation (i.e. LWC), the unnormalized density should be used.

The unnormalized density is simply calculated as

$$N_i = \mathrm{COUNTS}_i / \mathrm{VOL}_i \quad [\mathrm{counts}/\mathrm{M}^3]$$

where:
- N_i = Number density
- COUNTS = number of particles
- VOL = sampling volume
- i = channel number

2.1.1.7 Particle number density calculation (cont'd)

The normalized density is

$$N_i = COUNTS_i/(VOL_i \cdot BWMM_i)\text{[counts/M}^3\text{per mm barwidth]}$$

where:

BWMM = barwidth in mm

2.1.1.8 Editing capability

Examination of the raw counts for the 15 channels of any probe will show that at certain times the counts for a particular channel are invalid. (There are many reasons for this phenomenon which are not explained here; the cures, rather than the causes, are of concern to us and included in this section.) After looking at a few of the early 1D tapes, it became obvious that KNOLL1D would require some type of automatic editing capability.

It was decided that the edit routine be designed to correct the immediate problem only. If the probe channels deteriorate considerably a more sophisticated editing technique will have to be implemented. This technique has proved successful over the past 5 years, and there is no reason to expect any major changes.

Presently in order to alter the values of a given channel, there must be valid adjacent channel data. That is, there must be good data on each adjacent side of the channel to be edited. Of course, channels 1 and 15 are handled differently; in these cases two valid channels are expected on one side (channels 2 and 3 for editing channel 1; channels 13 and 14 for editing channel 15.)

For channels 2 through 14, a geometric progression is assumed; A count of 1 is added to the two valid channels so that a channel with a count of zero can be considered valid. A count of 1 is subtracted from the final result. The equation used is

2.1.1.8 Editing capability (cont'd)

$$C_i = \sqrt{(C_{(i+1)} + 1) \cdot (C_{(i-1)} + 1)} - 1$$

where:

C_i = counts
i = channel number ($2 \leq i \leq 14$)

Actually KNOLL1D uses the logarithmic representation of the equation $C_i = 10^a$

$$\text{where} \quad a = \frac{\{LOG(C_{(i+1)} + 1) + LOG(C_{(i-1)} + 1)\}}{2} - 1$$

For channels 1 and 15 a linear distribution is assumed and the desired channel is found by extrapolation. Using the sample distribution as shown the equations for these channels are readily seen in figure 2.4

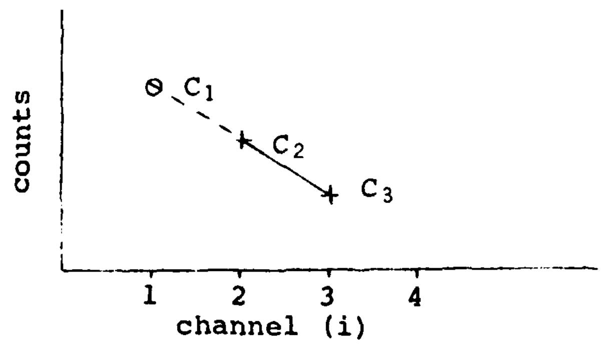


Figure 2.4: Extrapolating channel data

2.1.1.8 Editing capability (cont'd)

$$c_1 = mi + b$$

where $$m = \frac{c_3 - c_2}{3 - 2} = c_3 - c_2$$

and

$$b = c_2 - 2m = c_2 - 2(c_3 - c_2)$$
$$b = 3c_2 - 2c_3$$

substituting

$$c_1 = (c_3 - c_2)1 + (3c_2 - 2c_3)$$
$$c_1 = c_3 - c_2 + 3c_2 - 2c_3$$
$$c_1 = 2c_2 - c_3$$

reversing the subscripts for channel 15 the equation becomes

$$c_{15} = 2c_{14} - c_{13}$$

An additional capability of the edit routine allows channels 1 and 2 to be edited if channel 3 is valid. When desired, this allows channels 1 and 2 to equal channel 3.

2.1.1.9 Data modification

During the last five years DPSI has worked with individual members of the Cloud Physics Branch in the area of PMS-1D data modification. The procedure finally implemented is the result of many trials and revisions of the work done by the Branch scientists. The goal was, ultimately, to increase the calculated liquid water content and the radar reflectivity because of certain design shortcomings.

The justification for this modification is two fold. There are "blind spots" associated with the 1D instrument. A blind spot may be defined as that portion of the spectra which lies between the limits of two probes.

When the instrument is measuring water droplets there are no blind spots present. It is the ice crystal shadow length, being reduced to equivalent melted diameter, that causes the gap. These blind spots are a function of particle type.

For example, when measuring needles the uppper limit of the Cloud Probe is 142 microns and the lower limit of the precip probe is 241 microns, then the 1D instrument is "blind" to particles in the 142 to 241 micron range. Obviously this could have a serious effect on water content and reflectivity calculations.

A reasonable distribution was obtained by using the data in channels 12 through 15 to calculate new channel 13 and 14 values. Then a log interpolation was done between channel 14

2.1.1.9 Data modification (cont'd)

of the cloud and 2 of the precip probe to obtain the new 15 and 1 values. The center diameter and bandwidth of channel 1 were recalculated to eliminate any overlap.

The following flowchart describes subroutine BOBINT of KNOLL1D which optionally does the data modification.

2.1.1.9 Data modification (cont'd)

The abbreviations and terminology used in the BOBINT flowchart are described below:

BW	Barwdith
CD	Center diamter
ND	Normalized Number Density
LWC	Liquid Water Content
Z	Radar Reflectivity
CL	Cloud Probe
PR	Precip Probe
TOT	Total (Cloud & Precip combined)
#	Channel Number

Variable names are formed by concatenating a symbol from each group. For example:

ZCL15	Reflecting for Cloud Probe Channel 15
NDPR2	Number Density Precip Channel 2
LWCCL	Water Content Cloud Probe
ZTOT	Total Relectivity

FUNCTION ALINE:

```
ALINE(A,B,C,D,E) = 10.9**(((C-E)/(B-D)*(A-D))+E)
```

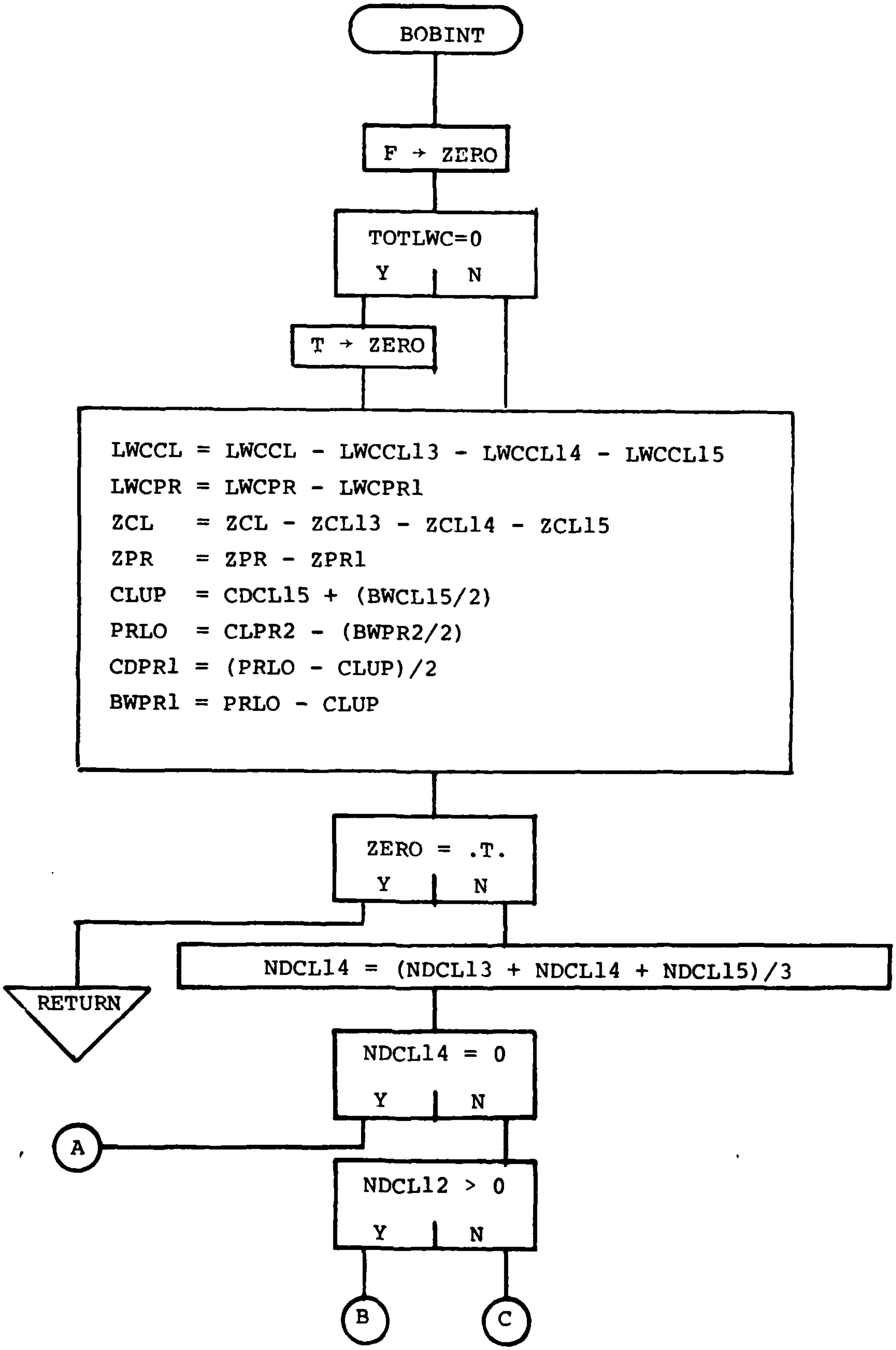
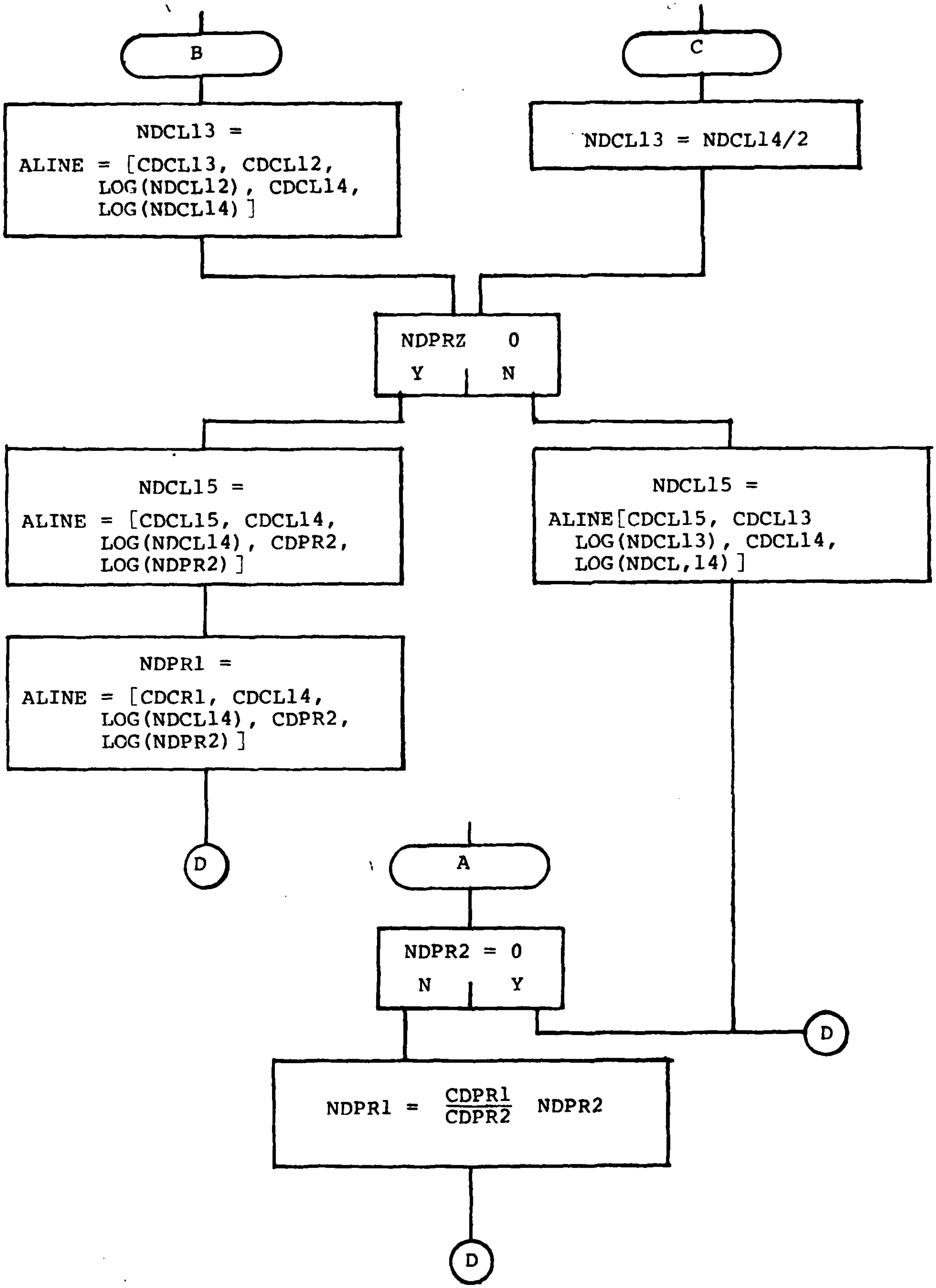
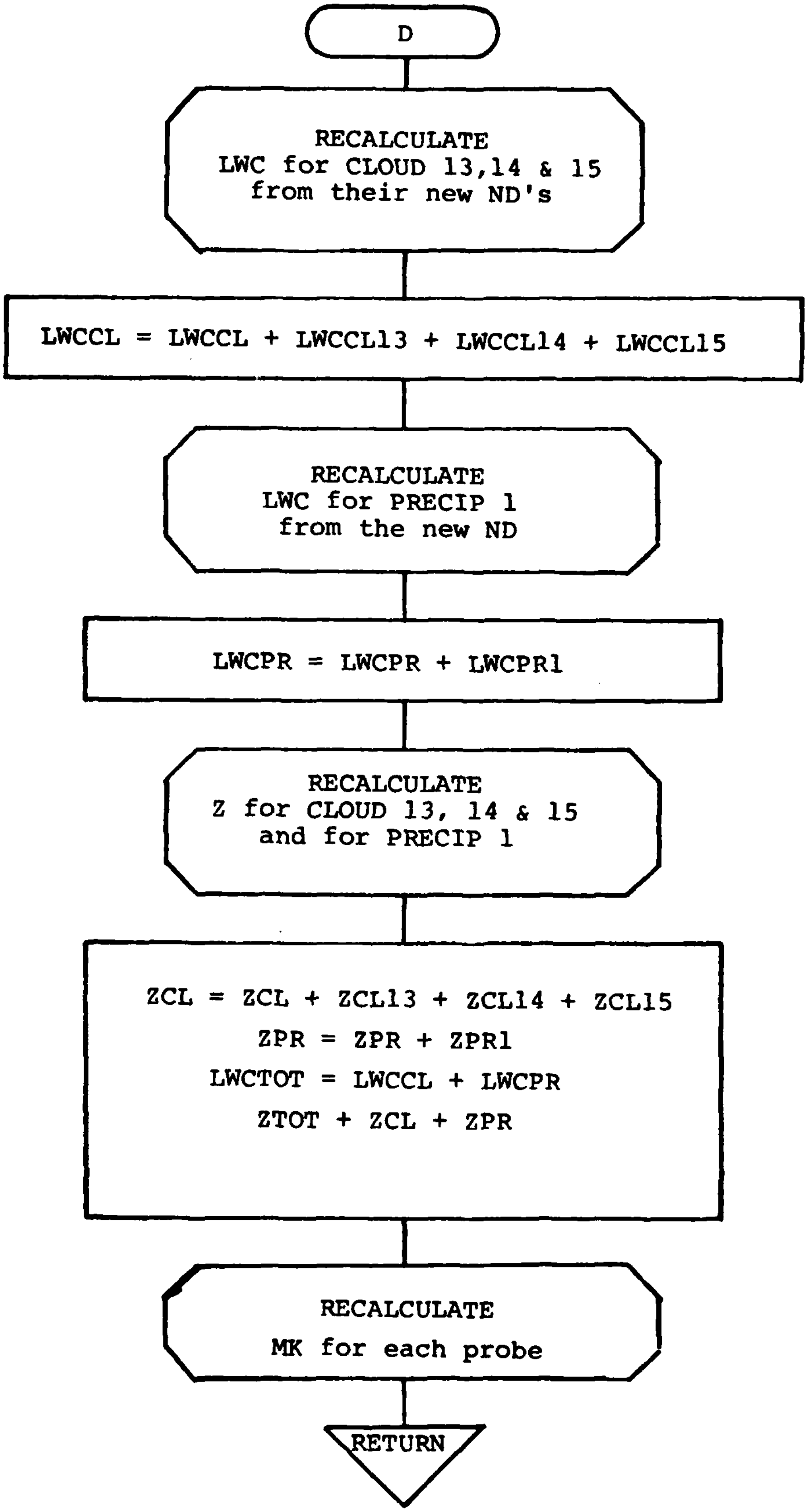


Figure 2.5 : BOBINT Flowchart


B
C
NDCL13 =
ALINE = [CDCL13, CDCL12, LOG(NDCL12), CDCL14, LOG(NDCL14)]
NDCL13 = NDCL14/2
NDPRZ 0
Y
N
NDCL15 =
ALINE = [CDCL15, CDCL14, LOG(NDCL14), CDPR2, LOG(NDPR2)]
NDCL15 =
ALINE[CDCL15, CDCL13 LOG(NDCL13), CDCL14, LOG(NDCL,14)]
NDPR1 =
ALINE = [CDCR1, CDCL14, LOG(NDCL14), CDPR2, LOG(NDPR2)]
D
A
NDPR2 = 0
N
Y
D
NDPR1 = CDPR1/CDPR2 NDPR2
D


D
RECALCULATE
LWC for CLOUD 13,14 & 15
from their new ND's
LWCCL = LWCCL + LWCCL13 + LWCCL14 + LWCCL15
RECALCULATE
LWC for PRECIP 1
from the new ND
LWCPR = LWCPR + LWCPR1
RECALCULATE
Z for CLOUD 13, 14 & 15
and for PRECIP 1
ZCL = ZCL + ZCL13 + ZCL14 + ZCL15
ZPR = ZPR + ZPR1
LWCTOT = LWCCL + LWCPR
ZTOT + ZCL + ZPR
RECALCULATE
MK for each probe
RETURN

2.1.1.10 Liquid water content calculation

The liquid water content (LWC) is calculated for each probe once per averaging interval using the average particle number density. In addition the total LWC is calculated, as the sum of the LWC from the Cloud and Precip Probes less any overlapping range. The equation used for this calculation is

$$LWC = \frac{\pi}{6} \rho \sum_{i=1}^{15} N_i D_i^{\,3}$$

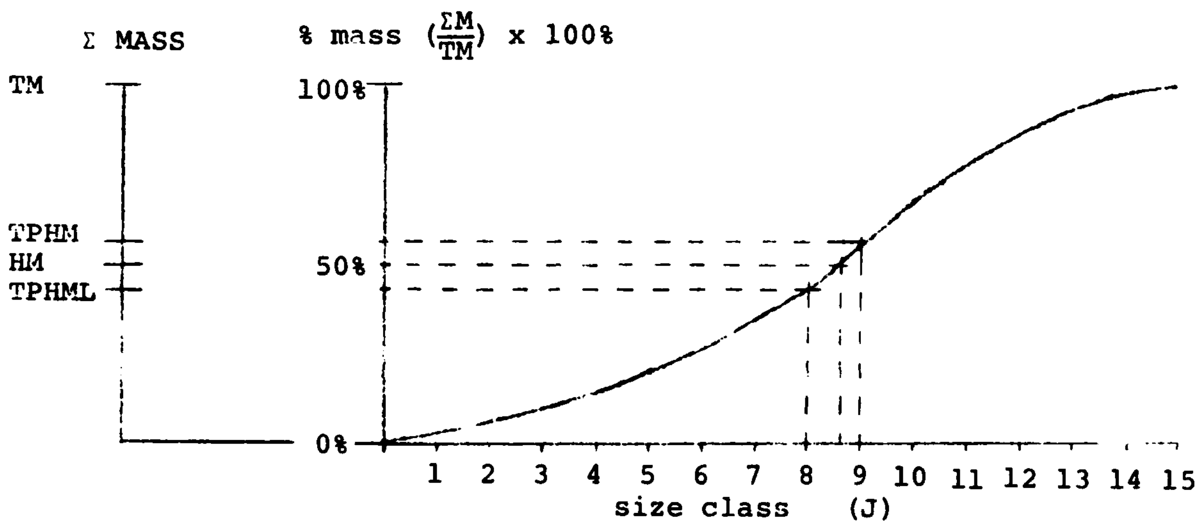
where: ρ = water density (10^{-3} gm/mm^3)

N_i = number density for channel i

D_i = center diameter for channel i

2.1.1.11 Median volume diameter determination

The median volume diameter is defined as: the diameter where the mass of all the particles smaller than it is one-half of the total mass of the sample being considered. Figure 2.6 graphically depicts this definition.



where:

TM	=	total mass
HM	=	TM/2 = one-half mass
TPHM	=	sum of the masses of the first J classes, [stopping when the total (TPHM) exceeds HM]
TPHML	=	Σ mass at class (J-1)
$D_{(i)}$	=	center diameter of class i
D_o	=	median volume diameter

Figure 2.6 : Median volume diameter

2.1.1.11 Median volume diameter determination (cont'd)

D_o is found by summing the mass of each channel until the sum exceeds one-half the total mass. At this time all the variables listed in Figure 2.6 are known. The following interpolation formula is used for the D_o calculation.

$$D_o = D(J)-BW(J) \cdot \left(\frac{1}{2} - \frac{(HM-TPHML)}{(TPHM-TPHML)}\right)$$

where: BW(J) = barwidth of class J

It should be emphasized that this calculation is performed using the average mass and average number densitites. These results may differ considerably from calculating D_o every second and then averaging the one second median volume diameters. An example will clearly show this difference.

Assume the following distribution for a two second interval

	Second 1		Second 2		Average	
ch#	Mass	ΣM	Mass	ΣM	Mass	ΣM
1	.001	.016	.001	.001	.001	.001
2	.015	.016	.002	.003	.0085	.0095
3	.200	.216	0	.003	.100	.1095
4	0	.216	0	.003	0	.1095
5	.180	.396	.201	.204	.1905	.300
6	0	.396	0	.204	0	.300
7	0	.396	0	.204	0	.300
8	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
15	0	.396	0	.204	0	.300

The parameters previously discussed are found on the next page.

2.1.1.11 Median volume diameter determination (cont'd)

		Second 1	Second 2	Average
TM	=	.396	.204	.300
HM	=	.198	.102	.150
TPHM	=	.216	.204	.300
TPHML	=	.016	.003	.1095
J	=	3	5	5

Make the following simplifying assumptions

$$D(3) = 900\mu;\ D(5) = 1500\mu;\ BW(3) = BW(5) = 300\mu$$

For second 1:

$$D_{o_1} = 900 - 300\ \left(\frac{1}{2} - \frac{.198-.016}{.216-.016}\right)$$

$$D_{o_1} = 900 - 300(.5-.91)$$

$$D_{o_1} = 900 - 300(-.41) = 900 + 123 = 1023\mu$$

For second 2:

$$D_{o_2} = 1500 - 300\left(\frac{1}{2} - \frac{.102-.003}{.204-.003}\right)$$

$$D_{o_2} = 1500 - 300(.5-.4925)$$

$$D_{o_2} = 1500 - 300(.0075) = 1500 - 2 = 1498\mu$$

For the average:

$$D_{o_A} = 1500 - 300\left(\frac{1}{2} - \frac{.150-.1095}{.300-.1095}\right)$$

$$D_{o_A} = 1500 - 300\ (.5-.2126)$$

$$D_{o_A} = 1500 - 300(.2874) = 1500 - 97 = 1413\mu$$

2.1.1.11 Median volume diameter determination (cont'd)

Now let $\bar{D}_o = (D_{o_1} + D_{o_2})/2$

$$\bar{D}_o = (1023 + 1498)/2$$

$$D_o = 2521/2 = 1260.5\mu$$

But $D_{o_A} = 1413\mu$

Thus if the median volume diameter were calculated every second, a 10.8% difference would be introduced.

2.1.1.12 Radar reflectivity calculation

The radar reflectivity (Z) is calculated for each probe once per averaging interval using the average particle number density. In addition the total Z is calculated as the sum of the Z from the Cloud and Precip Probes less any overlapping range (see section 2.1.1.13). The equation used for this calculation is

$$Z = \sum_{i=1}^{15} N_i \, D_i^{\,6}$$

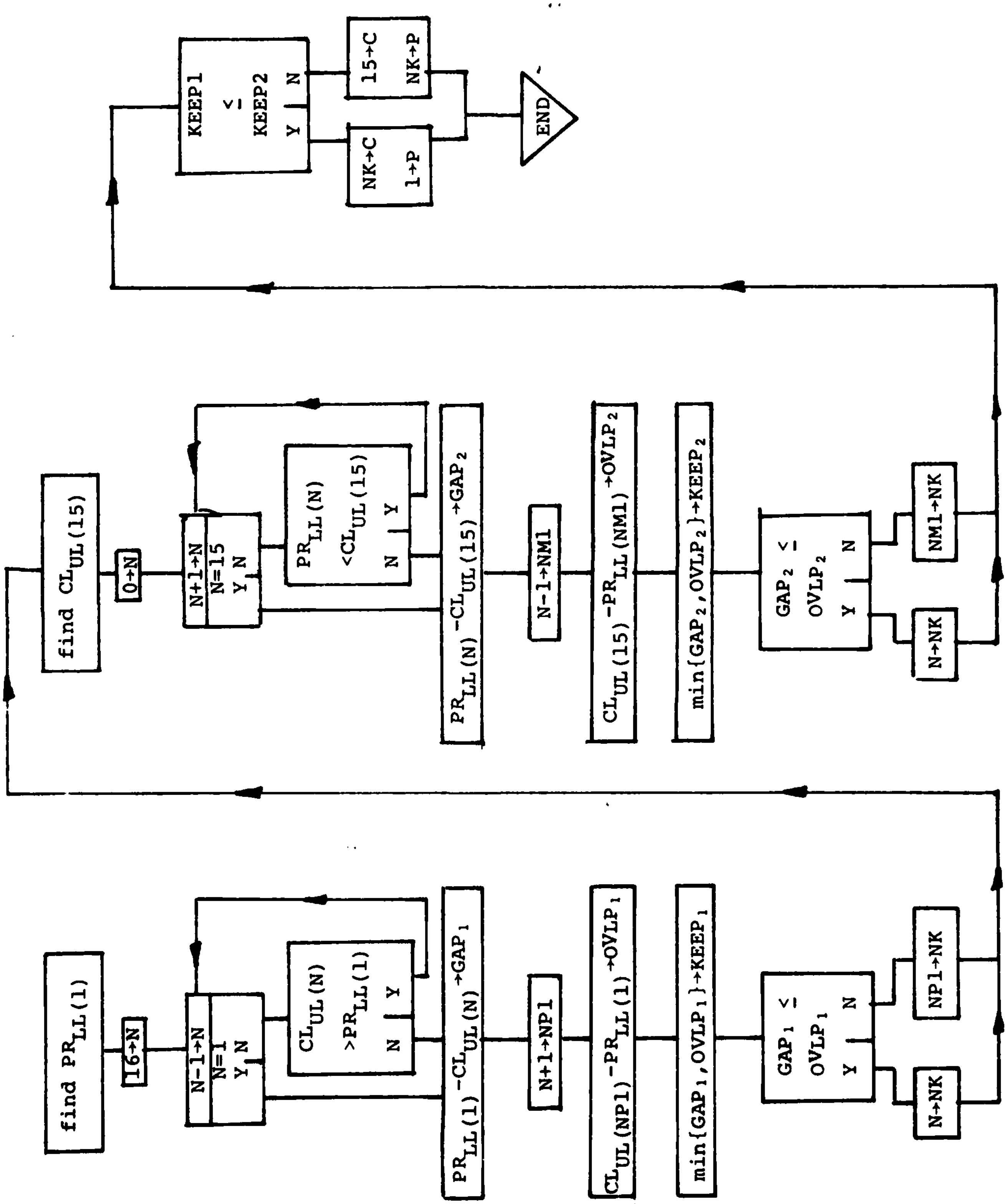
where: N_i = number density for channel i
D_i = center diameter for channel i

2.1.1.13 Channel overlap correction

The total LWC or Z is defined as the contributions derived from all 15 'loud and recip channels. However for some particle types there is an overlap between the upper cloud channels and the lower precip channels. This of course causes results somewhat higher than are correct.

An algorithm was written to eliminate these overlapping channels. It should be noted that calculations using a single probe include all fifteen channels. The overlap channel correction applies only to those calculations using both probes. The flowchart for this algorithm is found on the following page.

Figure 2.7: Overlap correction algorithm



2.1.1.14 Mass to reflectivity ratio

A useful parameter in the analysis of the PMS-1D data is the ratio of mass to radar reflectivity. This is calculated using the average mass and average reflectivity. Dimensionally, it is desirable to use the square root of the relectivity since M is a function of the diameter cubed and Z is a function of the diameter to the sixth power.

That is

$$K = M/\sqrt{Z}$$

where:

M is in grams/M^3 & Z is in mm^6/M^3

Using the square root of the reflectivity allows the numerator and denominator to be weighted equally. In some cases it is desirable to use M in mg/M^3. When this is the case, K is referred to as mK. This parameter is usually represented graphically, as the independent variable, where the mediam volume diameter is the dependent variable.

2.1.1.15 Form-factor calculation

The parameter form-factor which relates K to the total particle concentration is calculated as follows:

$$F = K/c\sqrt{N_T}$$

where:

K is defined in sec. 2.1.1.14

$c = \frac{\pi}{6}\, 10^{-3}$ M/mm

$$N_T = \sum_{i=17}^{45} N_i$$

$N_i = counts_i/Vol_i$

$counts_i$ = raw counts in channel i

vol_i = sampling volume of channel i

The notation $i=17 \rightarrow 45$ indicates the following

1. raw counts for the 15 Cloud Probe channels and 15 Precip Probe channels are in 30 continguous locations
2. an initial value of $i=17$ allows the first Cloud Probe channels to be eliminated

2.1.1.16 KNOLL1D operating instructions

```
CONTROL CARDS
DPSI,CM66000,T600,TP1.            PROB. NO.       NAME
ATTACH,LGO,KNOLL1DBIN,ID=GLASS,MR=1.
ATTACH,TAPE8,VCOCALS,ID=GLASS,MR=1.
REQUEST,TAPE1,S,HI,MT,VSN=PMSXXX.
REQUEST,TAPE2,*PF,SN=LYCPFI.*
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
LDSET,FILES=TAPE1,PRESET=ZERO.
MAP,OFF.
LGO.
EXIT(U).
CATALOG,TAPE2,PLOTDATA,ID=GLASS.*
REWIND,TAPE3,TAPE9.
COPY,TAPE3.
COPY,TAPE9.
REWIND,TAPE6.**
COPY,TAPE6.**
7/8/9
DATA CARDS
7/8/9
6/7/8/9
```

* FOR PLOTTAPE OPTION MUST HAVE REQUEST TAPE2 CARD

** FOR OPTIONAL OUTPUT

2.1.1.16 KNOLL1D operating instructions (cont'd)

DATA CARDS

CARD 1 - ID CARD

COL 1-10 FLT XYR-NN
COL 12-20 DD MON YR
COL 21-30 INPUT TAPE NUMBER
COL 31-40 PLOT TAPE NUMBER
COL 52-59 PMS ZERO SECONDS - HH:MM:SS

CARD 2 - NAMELIST SCOEF

ARRAY S(5) OF SOUNDING COEFFICIENTS (DEFAULTED INTERNALLY).

CARD 3 - NAMELIST VCOEF - USED TO OVERRIDE VCO CALIBRATIONS

ARRAY C(3,13) CONTAINING THE VCO CALIBRATION COEFFICIENTS IN THE FOLLOWING ORDER: INTERCEPT, FIRST DEGREE AND SECOND DEGREE COEFFICIENTS.
VCO'S ARE IN THE FOLLOWING ORDER:

1 INDICATED AIRSPEED
2 TEMPERATURE
3 EWER
4 TWCI-4
5 DEWPOINT/FROSTPOINT
6 LWC-JW
7 MAGNETIC HEADING
8 PRESSURE KISTLER
9 TRUE AIRSPEED
10 ICEING RATE
11 TWCI-1
12 TWCI-2
13 TWCI-3

CARD 4 - NAMELIST JWADJ

CONTAINS HEIGHT PROFILES FOR A JW-LWC ADJUSTMENT.
ELEMENTS ARE:

L NUMER OF LEVELS (DEFAULT 0-NO CORRECTION)(MAX 10)
HT HEIGHT OF LEVELS IN KM'S (HT(1) GT HT(2) GT...GT HT(L))
XA ORIGIN OF LEVEL (ONE PER LEVEL)
SLA SLOPE FROM LEVEL (I) TO LEVEL (I+1) (L-1 SLOPES REQUIRED

2.1.1.16 KNOLL1D operating instructions (cont'd)

CARD 5 - OPTION CARD (ALL I5 FORMAT)

```
COL  1-5   NFHEADR - SET TO 1 WHEN CONDENSED FORMAT HEADER
           CARD DESIRED
     6-10  ICLK 1     = USE A/C CLOCK
                2     = USE PMS CLOCK
    11-15  IDAT 1     = USE FINALIZED DATA LITERAL
                0     = USE PRELIMINARY LITERAL
    16-20  IPLT 1     = PLOT TAPE PRODUCED
                0     = NO PLOT TAPE
    21-25  N2PROBE 2 = TWO CLOUD PROBES
                   3 = TWO PRECIP PROBES
    26-30  ITMP 0     = TEMPERATURE DETERMINATION BY VCO PROFILE
                1     = TEMPERATURE DETERMINATION BY STANDARD
                        ATMOSPHERE
                2     = TEMPERATURE DETERMINATION BY RADIOSONDE
                        PROFILE
    31-35  JVCO - NUMBER OF VCOFIX CARDS DESIRED (0-10)
    36-40  NSKP       >0 IS THE NUMBER OF END-OF-FILES TO SKIP
                      BEFORE PROCESSING THE DATA
                      <0 IS THE NUMBER OF RECORDS TO SKIP BEFORE
                      PROCESSING THE DATA
    41-45  IDEK 1     = PRODUCE A PUNCHED DECK CONTAINING THE
                        TIME, HEIGHT, LWC AND D0 VALUES,
                        0 = NO DECK
    46-50  MXLINES - NUMBER OF PASS LITERALS DESIRED FOR THE
                      CONDENSED OUTPUT FORMAT (0-15)
    51-55  INTRP 1    = USE INTERPOLATION
                 0    = NO INTERPOLATION
    56-60  IDMZ  1    = SUMMARY FILE OF D0,LWC AND Z VALUES
                        PRODUCED
                 0    = NO SUMMARY FILE PRODUCED
    61-65  IVEL  1    = USE TRUE AIRSPEED
                 0    = USE CALCULATED AIRSPEED
    66-70  IFORM 1    = CONDENSED OUTPUT FORMAT PRINTED AND THE
                        PLOT TAPE USES UNMELTED BARWIDTH'S
                 0    = NORMAL OUTPUT AND NORMAL PLOT TAPE
    71-75  IOUT  1    = NO STANDARD OUTPUT
                 0    = STANDARD OUTPUT PRODUCES
    76-80  ISCAT 1    = USE .9 FACTOR IS SCATTER CALCULATIONS
                 0    = .9 FACTOR NOT USED
```

2.1.1.16 KNOLL1D operating instructions (cont'd)

```
CARD 6     NEW FORMAT HEADER CARD (IF NFHEADR .EQ. 1)
           CENTERED LINE (A80) TO BE PRINTED AT THE TOP OF EACH
           NEW FORMAT OUTPUT.

CARD 7     TYPE LITERAL LINE
           IF MXLINES > 0 MXLINES CARDS ARE REQUIRED HERE IN
           CENTERED A80 FORMAT.  THESE LINES ARE PRINTED ON
           NEW FORMAT OUTPUT; BENEATH THE INTERVAL PARTICLE
           TYPE.

CARD 8 ONWARDS

           A) ANY DATA CARDS REQUIRED BY SWITCHED SET ON OPTION
              CARD JVCO 0 IMPLIES VCO PROFILES IN HERE
              ITEMP=2 IMPLIED RADIOSONDE PROFILES HERE
           B) TYPE, EDIT, HTOX, XTOD CARDS INTERSPERED IN HERE

TYPE (15 MAXIMUM)

   COL  1-4  TYPE
   COL  6-13 HH:MM:SS (START TIME)
   COL 16-23 HH:MM:SS (STOP TIME)
   COL 25-26 CLOUD TYPE
   COL 27-28 PRECIP TYPE
   COL 31-35 AVERAGING INTERVAL (15)
   COL 45-64 LEFT JUSTIFIED PASS LITERAL FOR HEADER OF NEW
             FORMAT (A20)

EDIT (5 MAXIMUM)

   COL  1-4  EDIT
   COL  6-13 HH:MM:SS (START TIME)
   COL 16-23 HH:MM:SS (STOP TIME)
   COL 26,28,30 PROBES TO BE EDITED (1,2,3)
   COL 31-54 CHANNELS TO BE EDITED (I3 FORMAT, 8 MAXIMUM)

HTOX (NO MAXIMUM)

   COL  1-4  HTOX
   COL  6-7  TYPE CODE (ODD NUMBER)
   COL  9-10 EQUATION NUMBER
   COL 12-13 ARGUMENT TO BE CHANGED (1=M, 2=B, 3=BREAKPT)
   COL 15-30 NEW VALUE (F15.0)

XTOD (NO MAXIMUM)     SAME AS HTOX

   COL 12-13 ARGUMENT TO BE CHANGED (1=CO, 2=EX, 3=BREAKPT)
```

2.1.1.16 KNOLL1D operating instructions (cont'd)

Center Diameter & Barwidth Size Listings

A special feature of program KNOLL1D is the ability to produce a complete listing of all the center diameter and barwidth parameters that may be used. By using a standard KNOLL1D deck with minor modifications a listing may be obtained which contains this information for each channel of the cloud and precip probes; for each particle type, melted and unmelted, with interpolation or without.

DATA CARD CHANGES

OPTION CARD: COL 11-15 IDAT = -1 (RIGHT JUSTIFIED)

CONTROL CARDS

```
DPSI,CM66000,T600.            PROB. NO.           NAME
ATTACH,TAPE8,VCOCALS,ID=GLASS,MR=1.
ATTACH,LGO,KNOLL1DBIN,ID=GLASS,MR=1.
ATTACH,LIST,LISTDEFBIN,ID=GLASS,MR=1.
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
LDSET,FILES=TAPE1,PRESET=ZERO.
MAP,OFF
LOAD(LGO,LIST).
EXECUTE.
7/8/9
DATA CARDS
7/8/9
6/7/8/9
```

2.1.1.16 KNOLL1D operating instructions (cont'd)

Output file

KNOLL1D creates an optional output file, TAPE2, which is used by many other programs as their data base. This can be found in appendix 5. A listing of the VCO placement within this file will be found in appendix 6.

2.1.1.17 KNOLL1D sample output

The following pages are KNOLL1D sample output.

KNOLL 1D 3 X 85 X 16

5 MAR 79 E79-21

PROCESSED ON

FRIDAY

MAY 23 1980

19:03:22

```
FLIGHT INFO  FLT E79-21 5 MAR 79                                PROCESSED ON  05/23/80
PMS ON TIME   00:00:00  A/C CLOCK                                         AT  19:03:22
I/O OPTIONS
      INPUT TAPE : PMS247
    0 FILE(S)/RECORD(S) SKIPPED
      DATA   MODIFICATION : ON:
      PLOT    TAPE OUTPUT : ON:
      OMZ   LPPLOT OUTPUT : ON:
      SPECIAL DECK OUTPUT : OFF
      DATA TYPE : PRELIMINARY

TEMPERATURE DETERMINATION BY: VCC CALIBRATION
```

PARTICLE DETERMINATION BY: MANUAL ANALYSIS

10 TYPE CARD(S)

19:29:22	19:32:10	CLOUD=03	WET SNOW	PRECIP=03	WET SNCW	AVERAGING INTERVAL:	1 SECONDS
19:34:00	19:47:00	CLOUD=03	WET SNOW	PRECIP=03	WET SNCW	AVERAGING INTERVAL:	1 SECONDS
20:12:30	20:29:00	CLOUD=03	WET SNOW	PRECIP=03	WET SNCW	AVERAGING INTERVAL:	1 SECONDS
20:36:00	20:43:30	CLOUD=05	LARGE SNOW	PRECIP=05	LAPGE SNOW	AVERAGING INTERVAL:	1 SECONDS
20:50:45	20:57:30	CLOUD=03	WET SNOW	PRECIP=03	WET SNCW	AVERAGING INTERVAL:	1 SECONDS
21:05:30	21:22:45	CLOUD=03	WET SNOW	PRECIP=03	WET SNCW	AVERAGING INTERVAL:	1 SECONDS
21:29:30	21:40:00	CLOUD=05	LARGE SNOW	PRECIP=05	LARGE SNOW	AVERAGING INTERVAL:	1 SECONDS
21:44:45	22:02:30	CLOUD=05	LARGE SNOW	PRECIP=05	LARGE SNOW	AVERAGING INTERVAL:	1 SECONDS
[illegible]:37:00	22:24:30	CLOUD=05	LARGE SNOW	PRECIP=05	LARGE SNOW	AVERAGING INTERVAL:	1 SECONDS
[illegible]:32:00	22:42:00	CLOUD=01	PAIN	PRECIP=01	RAIN	AVERAGING INTERVAL:	1 SECONDS

VCO	PARAMETER	INTERCEPT	SLOPE	THIRD ORDER
1	INDICATED AIRSPEED	-.36060E+03	.10640E+00	-.42786E-05
2	TEMPERATURE	-.50805E+02	.10080E-01	0.
3	EWER	0.	.10000E+01	0.
4	TWCI-4	0.	.10000E+01	0.
5	DEWPOINT	-.49387E+02	.99418E-02	0.
6	LWC - JW	-.30268E+01	.61000E-03	0.
7	MAGNETIC HEADING	.17882E+03	-.36032E-01	0.
8	PRESSURE KISTLER	.11320E+04	-.99200E-01	-.16490E-06
9	TRUE AIRSPEED	-.65607E+02	.53490E-01	0.
10	ICING RATE	0.	.10000E+01	0.
11	TWCI-1	0.	.10000E+01	0.
12	TWCI-2	0.	.10000E+01	0.
13	TWCI-3	0.	.10000E+01	0.

SOUNDING COEFFICIENTS
S(1) = 9.308890E+00
S(2) = -1.815870E-02
S(3) = 1.308090E-05
S(4) = -3.761370E-09
S(5) = -4.079120E-13

C130 PROBE CONFIGURATION		CLOUD	PRECIP
DIODE WIDTH	(MM)	.020	.300
DEPTH OF FIELD	(M)	.061 (MAX)	.264
EFFECTIVE APETURE WIDTH (M)		(21-N)*WDM	(23-N)*WDM

HTOX TABLE

TYPE NUMBER	NAME	EQUATION NUMBER	ADJUSTED CLASS M	ADJUSTED CLASS B	BREAKPOINT (N)
1	RAIN	1	.990	.180	
3	WET SNOW	1	.990	.180	N LE 2.
		2	1.150	.180	
5	LARGE SNOW	1	1.150	.180	
7	SMALL SNOW	1	1.150	.180	
9	BULLET-ROSETTES	1	1.018	.318	
11	COLUMNS	1	1.302	.761	
13	NEEDLES	1	.200	3.040	N LE 1.
		2	1.280	1.080	
15	PLATE FAMILY	1	.938	.549	N LE 3.
		2	1.076	.819	
17	AGGREGATE P + D	1	.940	.550	N LE 3.
		2	1.208	-.440	
19	DENDRITE FAMILY	1	1.030	.716	
21	GRAUPEL	1	1.150	.180	
23	RIMED DENDRITE	1	1.150	.180	

TYPE NUMBER	**XTOD TABLE** NAME	EQUATION NUMBER	EQ MELTED DIAMETER CO	EX	BREAKPT (CRSIZ)
1	RAIN	1	1.000E+00	1.000	
3	WET SNOW	1	1.000E+00	1.000	C LE 1.000 MM
		2	1.000E+00	.653	
5	LARGE SNOW	1	4.000E-01	.782	
7	SMALL SNOW	1	4.000E-01	.782	C LE .500 MM
		2	3.700E-01	.670	
9	BULLET-ROSETTES	1	2.560E-01	.667	C LE .200 MM
		2	4.380E-01	1.000	
11	COLUMNS	1	4.380E-01	1.000	
13	NEEDLES	1	2.560E-01	.670	
15	PLATE FAMILY	1	3.400E-01	.783	C LE 1.000 MM
		2	3.400E-01	.685	
17	AGGREGATE P + D	1	3.400E-01	.783	C LE 1.000 MM
		2	3.400E-01	.685	
19	DENDRITE FAMILY	1	3.400E-01	.780	
21	GRAUPEL	1	6.000E-01	.910	C LE .410 MM
		2	4.900E-01	.680	C LE 1.350 MM
		3	4.600E-01	.900	
23	RIMED DENDRITE	1	4.600E-01	.900	

INTERVAL START TIME
=> A/C <= PMS
19:29:22 00:05:53

PMS TIME COUNTS 353
PMS ON TIME 00:00:00
PROCESSED ON 05/23/80

* FLT E79-21 ON 5 MAR 79 *
* 1 SECOND AVERAGE *
* PARTICLE TYPES *
*RAIN /WET SNOW /WET SNOW *

T C T A L S

	LMAX(MU)	4.884E+03
	FORM F	1.299E-01
	DO(MU)	1.200E+03
	NT(N/M**3)	2.993E+05
	MK(M/Z**.5)	3.605E+01
	LWC(G/M**3)	7.193E+00
	CUM AVE	(7.193E+00)
	Z(MM**6/M**3)	3.981E+04
	CUM AVE	(3.981E+04)

CH	SCATTER PROBE COUNTS (NUMB)	EQMD (MU)	NO. DENS. (N/M**3-MM)	LWC (G/M**3)	CLOUD PROBE COUNTS (NUMB)	EQMD (MU)	NO. DENS. (N/M**3-MM)	LWC (G/M**3)	PRECIP PROBE COUNTS (NUMB)	EQMD (MU)	NO. DENS. (N/M**3-MM)	LWC (G/M**3)
1	52	2	4.35E+08	5.78E-06	7	23	7.08E+06	9.40E-04	2703	4158	1.37E+05	9.73E-01
2	108	4	9.04F+08	7.55E-05	19	43	4.07E+06	4.22E-03	1381	647	1.75E+04	9.00E-01
3	215	6	1.80E+09	4.66E-04	22	72	2.07E+06	1.09E-02	540	1057	8.40E+03	1.00E+00
4	395	8	3.31E+09	1.95E-03	31	95	1.98E+06	2.09F-02	193	1265	4.88E+03	1.03E+00
5	710	10	5.94E+09	6.65E-03	21	118	9.14E+05	1.84E-02	74	1456	2.13E+03	6.39E-01
6	931	12	7.79E+09	1.48E-02	12	141	3.87E+05	1.32E-02	51	1635	1.66E+03	6.60E-01
7	1036	14	8.67E+09	2.58E-02	11	164	2.79E+05	1.50E-02	35	1804	1.27E+03	6.46E-01
8	851	16	7.12E+09	3.14E-02	5	187	1.05E+05	8.32E-03	5	1965	2.03E+02	1.27E-01
9	985	18	8.24E+09	5.14E-02	11	210	2.48E+05	2.79E-02	4	2119	1.81F+02	1.37E-01
10	526	20	4.40E+09	3.74E-02	7	233	1.72E+05	2.65E-02	3	2267	1.52E+02	1.35E-01
11	315	22	2.64E+09	2.97E-02	0	256	2.17E+05	4.41E-02	0	2411	0.	0.
12	165	24	1.38E+09	2.01E-02	4	279	1.20E+05	3.17E-02	1	2550	6.37E+01	7.58E-02
13	95	26	7.95E+08	1.47E-02	8	3028	1.90E+05	6.36E-02	0	2685	0.	0.
14	34	28	2.85E+08	6.53E-03	7	3258	3.01E+05	1.25E-01	1	2816	8.21E+01	1.25E-01
15	72	30	6.03E+08	1.70E-02	8	3488	2.46E+05	1.26E-01	0	2945	0.	0.
16									0			
LWC(G/M**3)			2.58E-01(2.58E-01)				5.36E-01(5.36E-01)				6.66E+00(6.66E+00)	
Z(MM**6/M**3)			4.45E-03(4.45E-03)				2.61E+01(2.61E+01)				3.98E+04(3.98E+04)	
MK(M/Z**.5)			3.87E+03				1.05E+02				3.34E+01	
DO(MICRONS)			1.90E+01				3.08E+02				1.21E+03	
NT(PROBE)			1.08E+08				4.13E+05				2.61E+04	

PRESSURE (MB)	574.34
EWER	24.00
ALTITUDE (METERS)	4530.83
TRUE-TEMP (DEG C)	-10.89
FROSTPOINT(DEG C)	-10.44
LWC-JW (G/M**3)	.20
LWC-IR (G/M**3)	0.00
LWC-TWCI (G/M**3)	0.00
IND AIRSPEED(KTS)	194.26
MAG HEADING (DEG)	236.04
AIRSPEED-C (M/S)	126.75
AIRSPEED-T *(M/S)	131.48
TWCI-1	0.00
TWCI-2	0.00
TWCI-3	0.00
TWCI-4	0.00
POTENTIAL TEMP(K)	307.29
DEWPOINT (C)	-12.32
SATURATED VAPOR(MB)	2.78
VAPOR(MB)	2.38
RELATIVE HUMID(%)	88.2

INTERVAL START TIME
=> A/C <= PMS
19:29:23 00:05:54

PMS TIME COUNTS 354
PMS ON TIME 00:00:00
PROCESSED ON 05/23/80

* FLT E79-21 ON 5 MAR 79 *
* 1 SECOND AVERAGE *
* PARTICLE TYPES *
*RAIN /WET SNOW /WET SNOW *

T C T A L S

	LMAX(MU)	5.229E+03
	FORM F	9.914E-02
	DO(MU)	1.126E+03
	NT(N/M**3)	3.872E+05
	MK(M/Z**.5)	3.230E+01
	LWC(G/M**3)	7.716E+00
	CUM AVE	(7.716E+00)
	Z(MM**6/M**3)	5.707E+04
	CUM AVE	(5.707E+04)

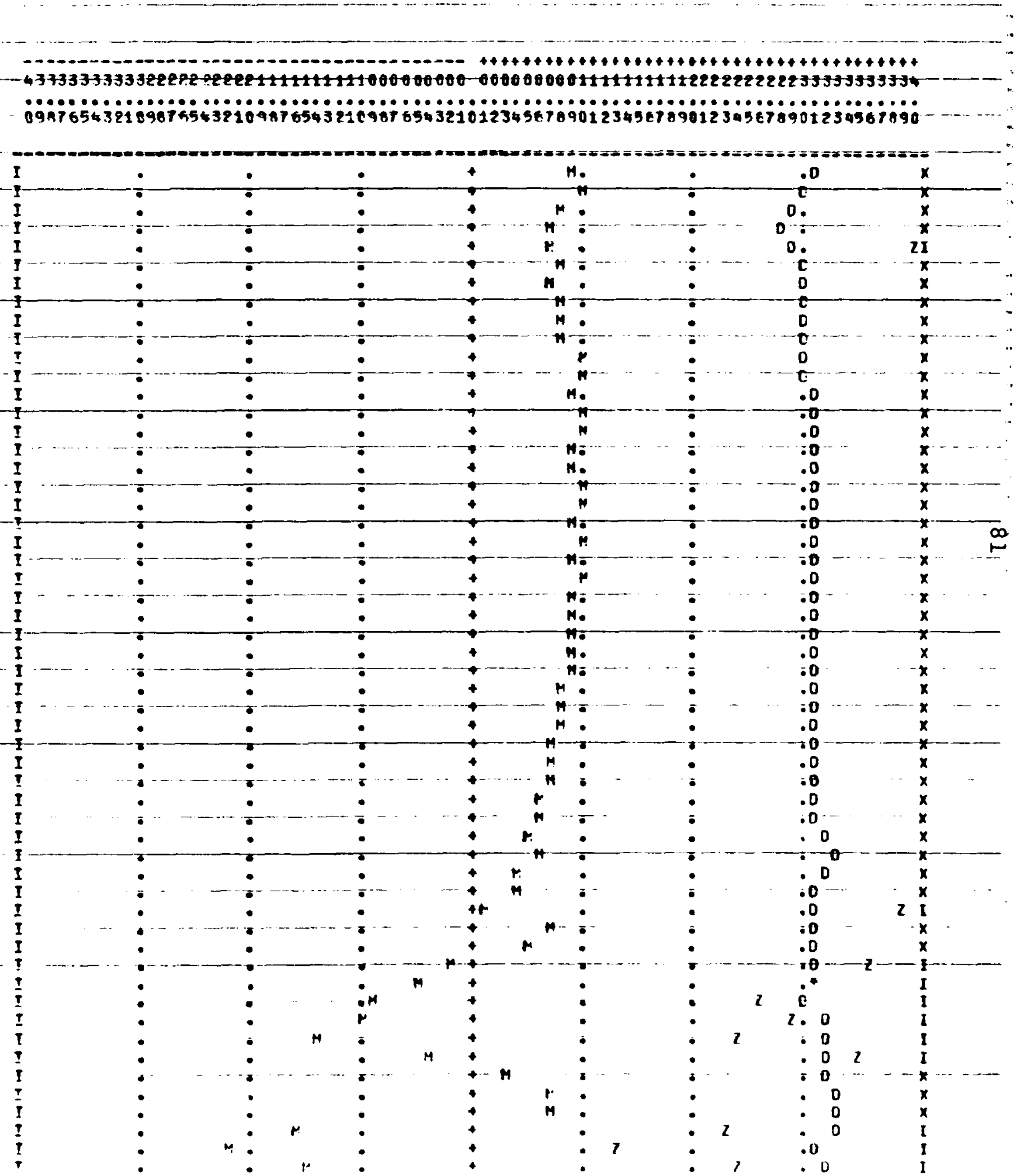
CH	SCATTER PROBE COUNTS (NUMB)	EQMD (MU)	NO. DENS. (N/M**3-MM)	LWC (G/M**3)	CLOUD PROBE COUNTS (NUMB)	EQMD (MU)	NO. DENS. (N/M**3-MM)	LWC (G/M**3)	PRECIP PROBE COUNTS (NUMB)	EQMD (MU)	NO. DENS. (N/M**3-MM)	LWC (G/M**3)
1	49	2	4.09E+08	5.43E-06	6	23	6.04E+06	8.03E-04	2168	4158	2.21E+05	9.27E-01
2	119	4	9.92E+08	8.29F-05	23	43	4.91E+06	5.10E-03	1852	647	1.62F+04	8.13E-01
3	232	6	1.93E+09	5.02E-04	19	72	1.79E+06	9.37F-03	452	1057	7.01F+03	1.34E+00
4	404	8	3.37E+09	1.98E-03	26	95	1.66E+06	1.74E-02	140	1265	3.53E+03	7.48E-01
5	695	10	5.80E+09	6.49E-03	25	118	1.08E+06	2.18E-02	70	1456	2.01E+03	6.02E-01
6	917	12	7.65E+09	1.45E-02	28	141	8.99E+05	3.07F-02	40	1635	1.30E+03	5.16E-01
7	1104	14	9.21E+09	2.74E-02	22	164	5.56E+05	2.99E-02	31	1804	1.12F+03	5.70E-01
8	972	16	8.11E+09	3.57E-02	25	187	5.21E+05	4.14F-02	10	1965	4.05E+02	2.54E-01
9	977	18	8.15E+09	5.08E-02	21	210	4.73E+05	5.32E-02	1	2119	4.52E+01	3.41E-02
10	513	20	4.28E+09	3.63E-02	16	233	3.93E+05	5.03E-02	1	2267	5.04E+01	4.49E-02
11	314	22	2.62E+09	2.95E-02	14	256	3.78F+05	7.69F-02	0	2411	0.	0.
12	150	24	1.25F+09	1.82E-02	16	279	4.80E+05	1.26E-01	2	2550	1.27E+02	1.51E-01
13	120	26	1.00E+09	1.84F-02	13	3028	5.42F+05	1.81F-01	0	2685	0.	0.
14	59	28	4.92E+08	1.13F-02	21	3258	6.11E+05	2.54E-01	2	2816	1.64E+02	2.49E-01
15	95	30	7.92E+08	2.23E-02	13	3488	4.72F+05	2.41E-01	2	2945	1.86E+02	3.20E-01
16									0			
LWC(G/M**3)			2.74E-01(2.74E-01)				1.15E+00(1.15E+00)				6.57E+00(6.57E+00)	

PRESSURE (MB)	574.04
EWER	24.00
ALTITUDE (METERS)	4540.83
TRUE-TEMP (DEG C)	-10.85
FROSTPOINT(DEG C)	-10.46
LWC-JW (G/M**3)	.22
LWC-IR (G/M**3)	0.00
LWC-TWCI (G/M**3)	0.00
IND AIRSPEED(KTS)	194.26
MAG HEADING (DEG)	236.04
AIRSPEED-C (M/S)	126.79
AIRSPEED-T *(M/S)	131.95
TWCI-1	0.00
TWCI-2	0.00
TWCI-3	0.00
TWCI-4	0.00
POTENTIAL TEMP(K)	307.39

TIME	--- LIQUID WATER CONTENT (GM/M**3) --- SCATTER	CLOUD	PRECIP	TOTAL	--- RADAR REFLECTIVITY(MM**6/M**3) --- SCATTER	CLOUD	PRECIP	TOTAL	---MEDIAN VOLUME DIAMETER(MICRONS)--- SCATTER	CLOUD	PRECIP	TOTAL
19:29:22	2.578E-01	5.364E-01	6.657E+00	7.193E+00	4.446E-03	2.608E+01	3.978E+04	3.981E+04	1.903E+01	3.078E+02	1.214E+03	1.208E+03
19:29:23	2.736E-01	1.149E+00	6.567E+00	7.716E+00	5.018E-03	5.703E+01	5.702E+04	5.707E+04	1.914E+01	3.040E+02	1.220E+03	1.126E+03
19:29:24	3.872E-01	2.139E+00	6.837E+00	8.977E+00	7.082E-03	1.052E+02	2.931E+04	2.942E+04	1.936E+01	3.011E+02	1.130E+03	9.182E+02
19:29:25	4.083E-01	1.550E+00	5.330E+00	6.880E+00	7.671E-03	7.623E+01	1.834E+04	1.842E+04	1.943E+01	3.048E+02	1.081E+03	8.118E+02
19:29:26	3.353E-01	1.428E+00	3.995E+00	5.423E+00	6.031E-03	7.051E+01	1.668E+04	1.675E+04	1.921E+01	3.039E+02	1.090E+03	6.414E+02
19:29:27	3.510E-01	1.093E+00	3.702E+00	4.795E+00	6.394E-03	5.391E+01	1.078E+04	1.083E+04	1.910E+01	3.052E+02	1.008E+03	7.154E+02
19:29:28	3.434E-01	1.174E+00	4.776E+00	5.958E+00	6.262E-03	5.981E+01	1.710E+04	1.716E+04	1.903E+01	3.072E+02	1.116E+03	9.621E+02
19:29:29	3.439E-01	1.266E+00	4.201E+00	5.467E+00	6.593E-03	6.245E+01	1.938E+04	1.944E+04	1.954E+01	3.009E+02	1.144E+03	9.2[illegible]0E+02
19:29:30	3.383E-01	1.348E+00	4.697E+00	6.044E+00	6.192E-03	4.779E+01	1.902E+04	1.909E+04	1.913E+01	3.068E+02	1.097E+03	9.090E+02
19:29:31	3.177E-01	1.113E+00	5.766E+00	6.879E+00	5.925E-03	5.638E+01	2.561E+04	2.566E+04	1.928E+01	3.097E+02	1.188E+03	1.054E+03
19:29:32	3.452E-01	1.029E+00	6.001E+00	7.030E+00	6.552E-03	4.787E+01	2.091E+04	2.096E+04	1.930E+01	2.957E+02	1.172E+03	1.100E+03
19:29:33	3.845E-01	2.141E+00	7.808E+00	9.949E+00	7.139E-03	9.720E+01	3.468E+04	3.478E+04	1.918E+01	2.908E+02	1.199E+03	1.007E+03
19:29:34	4.489E-01	2.059E+00	8.486E+00	1.055E+01	8.454E-03	1.005E+02	5.065E+04	5.075E+04	1.939E+01	3.005E+02	1.213E+03	1.082E+03
19:29:35	4.085E-01	1.196E+00	7.530E+00	8.726E+00	7.701E-03	5.626E+01	4.224E+04	4.230E+04	1.951E+01	2.958E+02	1.273E+03	1.178E+03
19:29:36	3.377E-01	1.105E+00	7.855E+00	8.960E+00	6.175E-03	5.145E+01	5.485E+04	5.495E+04	1.918E+01	2.956E+02	1.282E+03	1.200E+03
19:29:37	3.529E-01	8.890E-01	9.011E+00	9.900E+00	6.592E-03	4.193E+01	5.495E+04	5.499E+04	1.929E+01	2.974E+02	1.279E+03	1.220E+03
19:29:38	3.548E-01	6.610E-01	8.222E+00	8.883E+00	6.532E-03	2.877E+01	3.881E+04	3.884E+04	1.928E+01	2.835E+02	1.238E+03	1.199E+03
19:29:39	3.455E-01	7.399E-01	7.394E+00	8.134E+00	6.566E-03	3.407E+01	3.835E+04	3.838E+04	1.943E+01	2.962E+02	1.201E+03	1.187E+03
19:29:40	3.401E-01	6.946E-01	9.335E+00	1.003E+01	6.459E-03	2.999E+01	5.687E+04	5.690E+04	1.955E+01	2.856E+02	1.277E+03	1.238E+03
19:29:41	3.626E-01	7.382E-01	9.156E+00	9.954E+00	6.988E-03	3.843E+01	5.121E+04	5.125E+04	1.952E+01	3.002E+02	1.245E+03	1.190E+03
19:29:42	3.446E-01	3.995E-01	7.517E+00	7.917E+00	6.639E-03	3.719E+01	4.05[illegible]E+04	4.058E+04	1.962E+01	2.814E+02	1.211E+03	1.181E+03
19:29:43	3.528E-01	7.284E-01	8.299E+00	9.027E+00	6.708E-03	3.614E+01	3.522E+04	3.525E+04	1.945E+01	3.059E+02	1.206E+03	1.158E+03
19:29:44	3.691E-01	5.952E-01	8.049E+00	8.644E+00	6.957E-03	2.741E+01	4.765E+04	4.768E+04	1.994E+01	2.986E+02	1.249E+03	1.207E+03
19:29:45	3.366E-01	3.665E-01	8.988E+00	9.354E+00	6.432E-03	1.435E+01	6.407E+04	6.409E+04	1.959E+01	2.690E+02	1.289E+03	1.267E+03
19:29:46	3.271E-01	4.022E-01	8.213E+00	8.615E+00	6.177E-03	1.645E+01	6.675E+04	6.676E+04	1.937E+01	2.759E+02	1.285E+03	1.252E+03
19:29:47	2.990E-01	4.420E-01	7.255E+00	7.697E+00	5.587E-03	1.848E+01	3.175E+04	3.176E+04	1.939E+01	2.786E+02	1.198E+03	1.167E+03
19:29:48	3.207E-01	4.452E-01	7.817E+00	8.263E+00	5.977E-03	2.104E+01	4.894E+04	4.896E+04	1.946E+01	2.986E+02	1.279E+03	1.244E+03
19:29:49	2.755E-01	3.225E-01	8.277E+00	8.600E+00	5.316E-03	1.466E+01	5.756E+04	5.757E+04	1.983E+01	2.976E+02	1.291E+03	1.269E+03
19:29:50	2.873E-01	3.930E-01	7.038E+00	7.431E+00	5.405E-03	1.826E+01	5.101E+04	5.103E+04	1.943E+01	2.991E+02	1.282E+03	1.226E+03
19:29:51	2.399E-01	1.832E-01	5.555E+00	5.738E+00	4.457E-03	6.511E+00	3.395E+04	3.395E+04	1.922E+01	2.397E+02	1.228E+03	1.209E+03
19:29:52	2.736E-01	3.334E-01	6.661E+00	6.994E+00	5.311E-03	1.695E+01	4.560E+04	4.562E+04	1.963E+01	3.170E+02	1.255E+03	1.223E+03
19:29:53	2.820E-01	4.553E-01	6.471E+00	6.926E+00	5.351E-03	1.818E+01	3.370E+04	3.372E+04	1.951E+01	2.663E+02	1.242E+03	1.200E+03
19:29:54	2.511E-01	3.150E-01	5.024E+00	5.339E+00	4.519E-03	1.469E+01	2.287E+04	2.289E+04	1.926E+01	2.920E+02	1.170E+03	1.180E+03
19:29:55	1.824E-01	9.697E-02	4.716E+00	4.813E+00	3.219E-03	4.644E+00	2.347E+04	2.348E+04	1.911E+01	3.074E+02	1.176E+03	1.211E+03
19:29:56	1.654E-01	1.694E-01	4.483E+00	4.653E+00	2.792E-03	7.721E+00	1.996E+04	1.997E+04	1.897E+01	2.932E+02	1.172E+03	1.15[illegible]E+03
19:29:57	1.893E-01	1.333E-01	4.031E+00	4.165E+00	3.178E-03	6.102E+00	1.752E+04	1.752E+04	1.905E+01	3.123E+02	1.167E+03	1.194E+03
19:29:58	1.450E-01	1.519E-01	3.734E+00	3.886E+00	2.512E-03	6.899E+00	1.592E+04	1.593E+04	1.899E+01	2.926E+02	1.204E+03	1.183E+03
19:29:59	1.261E-01	2.773E-02	3.128E+00	3.156E+00	2.356E-03	4.463E-01	3.253E+04	3.253E+04	1.930E+01	1.772E+02	1.522E+03	1.514E+03
19:30:00	5.790E-02	9.727E-03	3.668E+00	3.678E+00	1.207E-03	4.222E-02	6.871E+04	6.871E+04	2.026E+01	1.378E+02	1.932E+03	1.930E+03
19:30:01	3.145E-02	1.292E-02	2.758E+00	2.771E+00	6.633E-04	6.938E-02	2.820E+04	2.820E+04	2.058E+01	1.401E+02	1.540E+03	1.537E+03
19:30:02	4.129E-02	6.444E-03	2.401E+00	2.407E+00	5.935E-04	7.794E-02	1.655E+04	1.655E+04	1.746E+01	1.357E+02	1.400E+03	1.339E+03
19:30:03	4.037E-02	3.898E-03	1.332E+00	1.336E+00	7.496E-04	1.100E-02	7.702E+03	7.702E+03	1.937E+01	1.063E+02	1.264E+03	1.263E+03
19:30:04	4.552E-02	9.109E-03	5.177E+00	5.186E+00	7.152E-04	3.718E-02	4.309E+04	4.309E+04	1.865E+01	1.060E+02	1.321E+03	1.320E+03
19:30:05	1.115E-01	3.743E-02	3.345E+00	3.382E+00	2.227E-03	1.891E+00	3.062E+04	3.063E+04	1.947E+01	3.210E+02	1.340E+03	1.334E+03
19:30:06	3.251E-02	6.161E-02	5.975E-01	6.591E-01	5.094E-04	3.254E+00	4.154E+03	4.157E+03	1.821E+01	3.104E+02	1.419E+03	1.352E+03
19:30:07	2.699E-02	3.488E-02	2.698E-01	3.047E-01	3.788E-04	1.447E+00	1.332E+03	1.334E+03	1.756E+01	2.887E+02	1.201E+03	1.166E+03
19:30:08	1.209E-02	8.089E-03	1.277E-01	1.358E-01	1.917E-04	5.387E-02	4.384E+02	4.384E+02	1.809E+01	1.546E+02	1.127E+03	1.094E+03
19:30:09	9.798E-03	2.128E-03	9.851E-02	1.006E-01	1.004E-04	6.870E-03	7.748E+02	7.748E+02	1.497E+01	1.068E+02	1.625E+03	1.618E+03
19:30:10	1.627E-02	6.478E-04	4.264E-02	4.328E-02	1.085E-04	1.880E-03	2.708E+02	2.708E+02	1.033E+01	9.560E+01	1.483E+03	1.481E+03
19:30:11	1.010E-02	0.	4.170E-01	4.170E-01	8.616E-06	0.	3.152E+03	3.152E+03	5.877E+00	0.	1.530E+03	1.530E+03
19:30:12	2.757E-02	2.569E-03	1.937E+00	1.939E+00	2.886E-04	8.733E-03	2.165E+04	2.165E+04	1.270E+01	1.237E+02	1.659E+03	1.659E+03
19:30:13	7.632E-02	5.255E-03	4.621E+00	4.627E+00	1.118E-03	2.184E-02	6.667E+04	6.667E+04	1.667E+01	1.221E+02	1.782E+03	1.782E+03
19:30:14	7.810E-02	2.445E-03	5.177E+00	5.180E+00	1.765E-03	3.698E-03	1.097E+05	1.097E+05	2.141E+01	7.835E+01	2.074E+03	2.073E+03
19:30:15	2.705E-02	0.	2.274E-02	2.274E-02	4.055E-04	0.	2.161E+02	2.161E+02	1.773E+01	0.	1.780E+03	1.780E+03
19:30:16	1.010E-02	8.280E-04	5.730E-03	6.558E-03	1.717E-05	2.638E-03	1.998E+01	1.998E+01	7.231E+00	1.186E+02	1.253E+03	1.236E+03
19:30:17	1.157E-02	4.685E-04	2.845E-02	2.892E-02	6.652E-06	3.424E-04	2.506E+02	2.506E+02	6.151E+00	7.260E+01	1.753E+03	1.750E+03
19:30:18	9.359E-03	0.	0.	0.	6.431E-06	0.	0.	0.	6.398E+00	0.	0.	0.
19:30:19	6.66[illegible]E-03	0.	0.	0.	5.248E-06	0.	0.	0.	6.805E+00	0.	0.	0.

FLIGHT#E79-21 DATE: 5 MAR 79

TIME	DB(MICRONS)	M(GM/M3)	Z(MM6/M3)
19:29:23	1.126E+03	7.716E+00	5.707E+04
19:29:24	9.182E+02	8.977E+00	2.942E+04
19:29:25	8.118E+02	6.880E+00	1.842E+04
19:29:26	6.414E+02	5.423E+00	1.675E+04
19:29:27	7.154E+02	4.795E+00	1.083E+04
19:29:28	9.621E+02	5.959E+00	1.716E+04
19:29:29	9.230E+02	5.467E+00	1.944E+04
19:29:30	9.090E+02	6.044E+00	1.909E+04
19:29:31	1.054E+03	6.879E+00	2.566E+04
19:29:32	1.100E+03	7.030E+00	2.896E+04
19:29:33	1.007E+03	9.949E+00	3.478E+04
19:29:34	1.082E+03	1.055E+01	5.075E+04
19:29:35	1.178E+03	8.726E+00	4.230E+04
19:29:36	1.208E+03	8.960E+00	5.495E+04
19:29:37	1.220E+03	9.900E+00	5.499E+04
19:29:38	1.195E+03	8.983E+00	3.884E+04
19:29:39	1.187E+03	8.134E+00	3.838E+04
19:29:40	1.238E+03	1.003E+01	5.690E+04
19:29:41	1.190E+03	9.954E+00	5.125E+04
19:29:42	1.181E+03	7.917E+00	4.058E+04
19:29:43	1.158E+03	9.027E+00	3.525E+04
19:29:44	1.207E+03	8.644E+00	4.768E+04
19:29:45	1.267E+03	9.354E+00	6.409E+04
19:29:46	1.252E+03	8.615E+00	6.676E+04
19:29:47	1.167E+03	7.697E+00	3.176E+04
19:29:48	1.244E+03	8.263E+00	4.896E+04
19:29:49	1.269E+03	8.600E+00	5.757E+04
19:29:50	1.226E+03	7.431E+00	5.103E+04
19:29:51	1.209E+03	5.738E+00	3.395E+04
19:29:52	1.223E+03	6.994E+00	4.562E+04
19:29:53	1.200E+03	6.926E+00	3.372E+04
19:29:54	1.180E+03	5.339E+00	2.289E+04
19:29:55	1.211E+03	4.813E+00	2.348E+04
19:29:56	1.152E+03	4.653E+00	1.997E+04
19:29:57	1.194E+03	4.165E+00	1.752E+04
19:29:58	1.183E 03	3.886E+00	1.593E+04
19:29:59	1.514E+03	3.156E+00	3.253E+04
19:30:00	1.930E+03	3.678E+00	6.871E+04
19:30:01	1.537E+03	2.771E+00	2.820E+04
19:30:02	1.399E+03	2.407E+00	1.655E+04
19:30:03	1.263E+03	1.336E+00	7.702E+03
19:30:04	1.320E+03	5.186E+00	4.309E+04
19:30:05	1.334E+03	3.382E+00	3.063E+04
19:30:06	1.352E+03	6.591E-01	4.157E+03
19:30:07	1.166E+03	3.047E-01	1.334E+03
19:30:08	1.094E+03	1.358E-01	4.384E+02
19:30:09	1.618E+03	1.006E-01	7.748E+02
19:30:10	1.481E+03	4.328E-02	2.708E+02
19:30:11	1.530E+03	4.170E-01	3.152E+03
19:30:12	1.659E+03	1.939E+00	2.165E+04
19:30:13	1.782E+03	4.627E+00	6.667E+04
19:30:14	2.073E+03	5.180E+00	1.097E+05
19:30:15	1.780E+03	2.274E-02	2.161E+02
19:30:16	1.236E+03	6.558E-03	1.998E+01
19:30:17	1.750E+03	2.832E-02	2.506E+02



2.1.2 Program KN1UTIL

KN1UTIL is a generalized tape utility program designed to operate on the PMS-1D input tape in order to verify the operation of the Knollenberg PMS 1D device. There are six different options the user may select. These options are listed here and further explained in the operating instructions found in section 2.1.2.1.

1. produce a decimal dump of a given number of files;
2. same as 1, above, except that the dump is in octal;
3. produce a selective decimal dump specifying a particular set or sets of records;
4. copy a tape specifying files and records to be copied;
5. produce a selective probe dump which will list only the channel counts of the selected probe.
6. produce a selective dump of the VCO channels only.

In addition to these options, three status files are created which may be listed at the users option. These files list in an easily readable format the three status words that appear in each record. Appendix 7 shows the format of these status words.

2.1.2.1 Program KN1UTIL operating instructions

CONTROL CARDS

```
DPSI,CM60000,T100,TP2.*            PROB. NO.        NAME
VSN,TAPE1=TAPENO,TAPE2=TAPENO.
ATTACH LGO,KN1UTILBIN,ID=GLASS,MR=1.
REQUEST,TAPE1,S,HI.
REQUEST,TAPE2,S,HI.
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
FILE(TAPE2,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
LDSET,FILES=TAPE1/TAPE2,PRESET=ZERO.
MAP,OFF.
LGO.
EXIT(U)
REWIND,BPARAM,CPARAM,DPARAM.**
COPY,BPARAM.**
COPY,CPARAM.**
COPY,DPARAM.**
7/8/9
DATA DECK
7/8/9
6/7/8/9
```

* IF NOT DUPLICATING A TAPE

1. CHANGE TP2 TO TP1
2. REMOVE TAPE2=TAPENO FROM VSN CARD
3. REMOVE REQUEST TAPE2 CARD

** REMOVE THE CARDS IF STATUS WORD DUMP IS NOT DESIRED

2.1.2.1 Program KN1UTIL operating instructions (cont'd)
DATA CARDS

1. Decimal Dump - one data card

cc 2-4	DEC
cc 5-7	number of files dumped
cc 8-10	record indicator i.e. 1 = every record 2 = every other record 6 = every sixth record

ex. to dump decimally, two files every 10th record

-DEC--2-10 - = blank

2. Octal Dump - one data card

cc 2-4	OCT
cc 5-7	same as decimal dump
cc 8-10	

ex. to dump octally, nine files every 100th record

-OCT--9100 - = blank

3. Selective Record Dump - n data cards (decimal only)

card 1

cc 2-4	REC
cc 5-7(rj)	number of files dumped
cc 8-10(rj)	record indicator

cards 2...n (one card for each set of records)

cc 1-6(rj)	starting record to dump
cc 7-12(rj)	ending record to dump

ex. to dump every 10th record
from 125 to 350 and
from 1000 to 1500

2.1.2.1 Program KN1UTIL operating instructions (cont'd)

```
-REC--1-10
---125---350
--1000--1500     - = blank
```

4. Tape Copying - n data cards

   card 1

cc 2-4	DUP
cc 5-7	number of files to copy

   cards 2...n (one card for each file to be copied)

cc 1-6(rj)	number of records to skip before copying
cc 7-12(rj)	number of records to copy

   ex. to create a tape of:
   records 701 to 750 from file 1,
   and records 25 to 50 from file 3,
   the data deck is ...

```
-DUP--3
---700----50
-----0-----0
----24----26     - = blank
```

5. Selective Probe Dump (1 data card)

cc 2-4	DEC
cc 5-7	number of files dumped
cc 8-10	record indicator i.e. 1 = every record 2 = every other record 6 = every sixth record
cc 15	selected probe

   BLANK/0 for regular decimal dump (OPTION 1)
   1 for Scatter Probe only
   2 for Cloud Probe only
   3 for Precip Probe only
   4 for VCO data only

2.1.2.1 Program KN1UTIL operating instructions (cont'd)

ex. to dump decimally, 2 files every 10th record for Precip Probe

-DEC--2-10----3 - = blank

2.1.2.2 Program KN1UTIL sample output

Output details

The DEC (decimal) and SEL (selected) output listings are shown in figure 2.8 and are identical in format. The R= and F= indicate the record and file numbers respectively. The format of this output is the same as the 64 word record structure illustrated in Appendix 8.

The probe select option of the decimal output is shown in figure 2.9. In this case the VCO data was chosen (a 4 in column 15 of the DEC card). The first number on each data line is the PMS elapsed second counter followed by the probe designator, in this case VCO data. The thirteen VCO values follow. The real time clock (hours, minutes and seconds) output is at the end of the line.

The last set of output (Figure 2.10) is a listing of the status parameters. The literal B0, C0 or D0 denote the probe; Scatter, Cloud or Precip. The first column lists the elapsed second counter. The next column shows the real time clock. The number in parenthesis at the top of this column is the elapsed second corresponding to this time. Thus since this number is 2, the elapsed seconds corresponding to this time is two more than that given in the first column. The other columns are the status values corresponding to the elapsed second counter ending in that particular digit. Refer to Appendix 7 for a listing of the parameters monitored each second.

761	6613	4392	5004	0	4153	4965	3061	5983	5034	0	0	0	0	5320	14
262	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
762	6611	4403	5004	0	4154	4386	3050	5983	5053	0	0	0	0	5321	14
2019	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1374	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2256	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
763	6629	4408	5004	0	4134	4884	3051	5986	5066	0	0	0	0	5322	14
2378	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1554	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4085	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

= 1, R= 200

360	6664	4007	5004	0	4261	4919	4361	6283	5211	0	0	0	0	5539	14
1485	1	9	4	3	4	1	2	3	2	1	0	0	1	0	0
1504	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0
1465	193	76	9	2	0	0	0	0	0	0	0	0	0	0	0
361	6665	3992	5004	0	4261	4334	4343	6284	5209	0	0	0	0	5540	14
317	1	8	7	8	2	4	3	1	2	1	0	0	1	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133	239	63	8	1	0	0	0	0	0	0	0	0	0	0	0
362	6673	3390	5004	0	4263	4345	4323	6286	5214	0	0	0	0	5541	14
2020	1	4	3	3	1	1	2	1	1	2	1	1	3	0	0
1353	0	0	0	1	1	0	0	0	0	0	0	0	2	0	0
2095	132	91	11	1	0	0	0	0	0	0	0	0	0	0	0
363	6697	3999	5004	0	4265	4350	4306	6286	5232	0	0	0	0	5542	14
2123	1	0	9	3	4	0	3	2	2	2	0	1	0	2	0
1484	0	0	0	1	0	0	1	0	0	0	2	0	0	0	0
4114	215	143	14	2	1	0	0	0	0	0	0	0	0	0	0

= 1, R= 250

160	6601	3673	5004	0	4361	4978	4436	6593	5222	0	0	0	0	5359	14
1486	0	1	3	5	2	0	2	1	0	1	0	0	0	0	0
1504	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
1485	114	22	1	0	0	0	0	0	0	0	0	1	0	0	0

Figure 2.8: KN1UTIL Decimal & Selected Output Listing

```
F=  1,     R=  550
  SECONDS = 936   VCO   DATA    7344  3268  5000     0  5231  4891  2569  7297  6543     0     0     0     0  17:09:35
  SECONDS = 937   VCO   DATA    7342  3262  5000     0  5230  4890  2564  7290  6536     0     0     0     0  17:09:36
  SECONDS = 936   VCO   DATA    7340  3257  5000     0  5231  4892  2583  7290  6534     0     0     0     0  17:09:37
  SECONDS = 939   VCO   DATA    7345  3254  5000     0  5230  4890  2583  7293  6532     0     0     0     0  17:09:38

F=  1,     R=  600
  SECONDS = 136   VCO   DATA    7096  2972  5001     0  5255  4901  2749  7403  6233     0     0     0     0  17:12:55
  SECONDS = 137   VCO   DATA    7091  2969  5000     0  5254  4901  2749  7405  6233     0     0     0     0  17:12:56
  SECONDS = 136   VCO   DATA    7092  2967  5001     0  5254  4900  2749  7406  6230     0     0     0     0  17:12:57
  SECONDS = 139   VCO   DATA    7090  2964  5000     0  5254  4901  2749  7408  6236     0     0     0     0  17:12:58

F=  1,     R=  650
  SECONDS = 336   VCO   DATA    6807  2806  5001     0  5289  4867  2593  7554  5872     0     0     0     0  17:16:15
  SECONDS = 337   VCO   DATA    6804  2802  5001     0  5290  4865  2593  7556  5868     0     0     0     0  17:16:16
  SECONDS = 338   VCO   DATA    6804  2801  5000     0  5290  4887  2593  7556  5866     0     0     0     0  17:16:17
  SECONDS = 339   VCO   DATA    6802  2797  5001     0  5290  4887  2593  7556  5865     0     0     0     0  17:16:18

F=  1,     R=  700
  SECONDS = 536   VCO   DATA    6816  2662  5001     0  5306  4880  2525  7627  5919     0     0     0     0  17:19:35
     ONDS = 537   VCO   DATA    6822  2663  5000     0  5307  4880  2525  7627  5926     0     0     0     0  17:19:36
     ONDS = 53c   VCO   DATA    6825  2665  5001     0  5306  4679  2524  7627  5933     0     0     0     0  17:19:37
     ONDS = 539   VCO   DATA    6827  2667  5000     0  5306  4881  2525  7626  5937     0     0     0     0  17:19:38

     ,     R=  750
     ONDS = 736   VCO   DATA    7096  2800  4999     0  5295  4880  3159  7624  6321     0     0     0     0  17:22:55
     ONDS = 737   VCO   DATA    7077  2801  4998     0  5295  4852  3159  7625  6314     0     0     0     0  17:22:56
  SECONDS = 738   VCO   DATA    7075  2799  4999     0  5295  4881  3159  7624  6313     0     0     0     0  17:22:57
  SECONDS = 739   VCO   DATA    7074  2600  4999     0  5295  4881  3159  7626  6316     0     0     0     0  17:22:58

F=  1,     R=  800
  SECONDS = 936   VCO   DATA    7166  2789  4999     0  5293  4872  3218  7677  6439     0     0     0     0  17:26:15
  SECONDS = 937   VCO   DATA    7172  2792  4999     0  5299  4874  3218  7632  6448     0     0     0     0  17:26:16
  SECONDS = 937   VCO   DATA    7172  2792  4999     0  5293  4874  3218  7632  6448     0     0     0     0  17:26:16
  SECONDS = 936   VCO   DATA    7176  2796  4999     0  5298  4872  3212  7631  6454     0     0     0     0  17:26:17
  SECONDS = 939   VCO   DATA    7183  2800  5000     0  5293  4873  3208  7630  6464     0     0     0     0  17:26:18

F=  1,     R=  850
  SECONDS = 136   VCO   DATA    7236  2793  5000     0  5295  4869  3208  7615  6530     0     0     0     0  17:29:35
  SECONDS = 137   VCO   DATA    7236  2794  4999     0  5295  4870  3204  7615  6530     0     0     0     0  17:29:36
  SECONDS = 138   VCO   DATA    7236  2794  4999     0  5295  4870  3199  7615  6535     0     0     0     0  17:29:37
  SECONDS = 139   VCO   DATA    7235  2795  5000     0  5295  4869  3198  7615  6532     0     0     0     0  17:29:38

F=  1,     R=  900
  SECONDS = 336   VCO   DATA    7136  2719  4999     0  5295  4873  3304  7630  6422     0     0     0     0  17:32:55
  SECONDS = 337   VCO   DATA    7137  2719  4999     0  5295  4871  3296  7639  6423     0     0     0     0  17:32:56
  SECONDS = 338   VCO   DATA    7137  2721  4999     0  5295  4870  3296  7639  6423     0     0     0     0  17:32:57
  SECONDS = 339   VCO   DATA    7138  2722  5000     0  5295  4871  3295  7638  6425     0     0     0     0  17:32:58

F=  1,     R=  950
  SECONDS = 536   VCO   DATA    7203  2777  5000     0  5297  4864  3188  7630  6535     0     0     0     0  17:36:15
  SECONDS = 537   VCO   DATA    7212  2776  4999     0  5295  4864  3186  7630  6539     0     0     0     0  17:36:16
  SECONDS = 538   VCO   DATA    7212  2777  4999     0  5297  4862  3178  7630  6537     0     0     0     0  17:36:17
  SECONDS = 539   VCO   DATA    7219  2778  4999     0  5296  4864  3178  7630  6532     0     0     0     0  17:36:18
```

Figure 2.9: KN1UTIL Probe Select Option

FSEC	HHMMSS(?)	0	1	2	3	4	5	6	7	8	9
850	190451	1508	91	1289	1165	1556	2756	5147	2217	1507	91
860	190501	1508	91	1352	1154	1555	2756	5147	2217	1508	91
870	190511	1507	91	1374	1167	1555	2757	5146	2218	1507	91
880	190521	1508	91	1360	1165	1555	2757	5147	2217	1508	91
890	190531	1507	91	1351	1144	1555	2756	5147	2218	1507	91
900	190541	1508	91	1330	1119	1555	2756	5147	2218	1507	92
910	190551	1507	91	1303	1090	1556	2756	5147	2219	150[illegible]	91
920	190601	1507	91	1319	1121	1555	2756	5146	2219	1507	92
930	190611	1507	91	1362	1172	1555	2755	5146	2219	1508	91
940	190621	1507	91	1361	1171	1555	2755	5147	2219	1508	91
950	190631	1507	91	1360	1167	1555	2756	5147	2219	1506	91
960	190641	1507	92	1356	1155	1556	2756	5146	2220	1508	91
970	190651	1507	92	1347	1139	1556	2756	5147	2220	1508	91
980	190701	1507	92	1334	1120	1556	2755	5147	2221	1507	92
990	190711	1507	91	1308	1090	1556	2755	5147	2221	1507	91
0	190721	1508	91	1293	1069	1556	2755	5147	2221	1508	91
10	190731	1507	92	1299	1084	1555	2756	5146	2222	1508	91
20	190741	1507	92	1336	1131	1556	2755	5147	2222	1507	92
30	190751	1507	92	1364	1165	1556	2755	5147	2222	1507	91
40	190801	1508	91	1366	1164	1556	2755	5146	2223	1507	92
50	190811	1507	92	1365	1163	1555	2755	5147	2223	1507	92
60	190821	1507	91	1362	1156	1556	2754	5147	2223	1507	92
70	190831	1507	91	1349	1145	1555	2755	5146	2224	1507	91
80	190841	1508	91	1347	1128	1556	2755	5147	2223	1508	91
90	190851	1508	91	1325	1106	1555	2755	5147	2224	1508	91
100	190901	1507	92	1305	1079	1555	2756	5146	2224	1508	91
110	190911	1508	91	1283	1097	1555	2755	5147	2224	1506	91
120	190921	1508	91	1363	1161	1555	2755	5147	2225	1507	92
130	190931	1507	91	1363	1159	1556	2755	5147	2225	1507	92
140	190941	1507	92	1366	1158	1555	2755	5146	2226	1507	92
150	190951	1507	91	1359	1147	1555	2755	5146	2226	1507	92
160	191001	1507	92	1344	1131	1556	2754	5146	2226	1506	91
170	191011	1508	91	1323	1111	1555	2755	5147	2226	1508	91
180	191021	1508	91	1307	1077	1556	2755	5147	2226	1508	92
190	191031	1507	92	1293	1058	1556	2755	5146	2227	1507	92
200	191041	1507	92	1300	1077	1555	2755	5147	2227	1508	92
210	191051	1507	92	1354	1129	1555	2755	5147	2228	1507	92
220	191101	1509	92	1370	1155	1555	2756	5147	2228	1507	92
230	191111	1508	91	1377	1153	1555	2756	5147	2228	1507	92
240	191121	1507	92	1369	1151	1555	2756	5147	2228	1508	91
250	191131	1503	91	1374	1144	1556	2755	5147	2229	1507	92
260	191141	1507	92	133[illegible]	1077	1556	2755	5147	2229	1507	92
270	191151	1507	92	130[illegible]	1059	1555	2756	5147	2229	1507	92
280	191201	1507	92	132	1115	1556	2755	5147	2229	1506	91
290	191211	1507	92	13[illegible]	1150	1555	2754	5146	2230	1507	92
300	191221	1507	92	137[illegible]	1157	1556	2754	5147	2230	1507	92
310	191231	1507	92	1359	1155	1555	2755	5147	2230	1507	92
320	191241	1507	91	1361	1154	1555	2755	5147	2230	1508	91
330	191251	1509	91	1362	1151	1555	2756	5147	2231	1507	91
340	191301	1508	91	1355	1134	1556	2755	5147	2231	1507	91

Figure 2.10: KN1UTIL Status Parameters

2.1.3 Program KNPLT1D

This program produces six different types of plots displaying the processed PMS-1D data in different forms. The input tape used is produced by program KNOLL1D (see appendix 2) for the tape format); it contains averaged data, one record per average interval. In addition the program can read a processed tape containing Learjet data. These tapes are preprocessed by another contractor and sent to LYC. We run HIAC1D on the reduced data tape to calculate additional parameters and create an output tape compatible to that of KNOLL1D.

Each plot type to be produced requires one plot request card. This card contains the information necessary to produce the plot (start time, stop time, etc.) with the appropriate title. The details of the plot request cards are included in the operating instructions.

To reduce plotting time and paper consumption the plots are produced on 105mm film. The following sections explain in detail the plots available and the calculations performed.

KNPLT1D is a program requiring large computer resources. For this reason DPSI h it advantageous to write several small redundant programs to duplicate these plots. These programs (ex. PLTD0) use the KNOLL1D processed tape (TAPE2) and generate the desired plots. Their sections will reference the following ones when appropriate.

2.1.3.1 Z-M scatter diagrams

This option produces two scatter diagrams of mass (M) in gms/M^3 vs. reflectivity (Z) in mm^6/m^3 on a full log scale. The first plot uses Precip Probe data only, the second uses Cloud and Precip combined. Any mass value outside the range of 10^{-4} through 10^{+1} or less than a specified minimum value is not plotted. The reflectivity limits are 10^{-4} and 10^{+5}.

A least square logarithmic fit is calculated and drawn through the data. The equation of this line is included on the plot in the form

$$M = a\ Z^{b}$$

The output listing for this plot type includes the equation coefficients (both linear and exponential), the average Z and M values, with their standard deviations.

2.1.3.2 Z-M histograms

This option produces two histograms; the first mass (M) vs time and the second reflectivity (Z) vs time. The plots are produced using a semi-log scale. The Z and M plot limits are the same as those defined above. The time axis is expressed in units of seconds from a given start time. These plots restrict the data to five minutes only. Any data exceeding this maximum will be ignored.

Each plot has three traces, one per probe, with a different plotting symbol used for each probe. A square indicates data from the scatter probe, a circle represents cloud data, and a triangle is used for Precipitation data. The output listing shows only the number of points plotted per trace.

If the mass is outside a specified range, the plotted values for M and Z will have their points overplotted with an "*".

2.1.3.3 VCO histograms

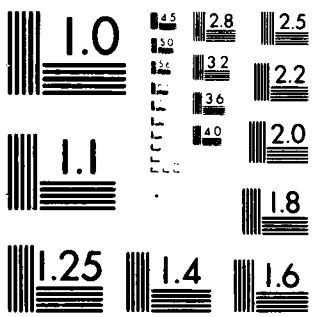
This option produces three VCO histograms, each consisting of two lines. The VCO's plotted are: pressure, temperature, heading, dewpoint, acceleration, and J-W water content. The plots are used exclusively for system verification and are not published outside the laboratory. For this reason there is no title, pass or other identification on the plot. The time axis is similar to the Z-M histograms and also has the same five minute maximum.

The acceleration and water content plots have fixed scales; the others have a sliding scale with a fixed maximum range. The limits used for the sliding scale plots are a function of the data to be plotted. They are determined automatically by the program. The table below shows the pertinent axis information. The output listing for this plot shows only the number of points plotted.

PLOT#	VCO	UNITS	SYMBOL	AXIS TYPE	AXIS LIMITS
1	pressure acceleration	mb g	Δ +	sliding fixed	30 mb max -1 to +1
2	temperature dewpoint	deg C deg C	Δ +	sliding sliding	12° max 12° max
3	heading JW-LWC	deg gm/M^3	Δ +	sliding fixed	60° max -.1 to +.8

AD-A109 929 DIGITAL PROGRAMMING SERVICES INC WALTHAM MASS F/G 4/2
DEVELOPMENT AND APPLICATIONS OF TECHNIQUES TO PROCESS HYDROMETE--ETC(U)
JUL 81 L E BELKSY, F B KAPLAN, J P LALLY F19628-78-C-0131
UNCLASSIFIED AFGL-TR-81-0261 NL

2 of 7
AD
A109929



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2.1.3.4 Density spectra

This option produces for a selected probe six plots per page of the $\log_{10}$ of number density vs the equivalent melted diameter. The six pictures, rather than one, results from the fact that it is desired to examine this plot separately as liquid water content (LWC) increases. Thus the procedure is to first determine the combined LWC for the cloud and precip probes and determine, as a function of the LWC, which of the six plots is to be used to display the data; then the appropriate $\log_{10}$ of the number density and equivalent melted diameter is retrieved to produce the plotting points within the plot selected. The LWC limits for the six plots are defined on the plot request card. The details of this card are shown in the operating instructions.

After all this data has been plotted additional calculations are performed. These calculations, (different types of averaging) are shown in the following ten steps.

1. Two parameters must be calculated before the averages can be calculated.

These are ...

ICNTX(N) and
SUMX(N) for N = classes 1 to 15

where $$\text{SUMX(N)} \sum_{i=1}^{\text{ICNTX(N)}} \text{DENSITY(N)}_i$$

ICNTX(N) = the number of samples in each class N

2.1.3.4 Density spectra (cont'd)

note: The normalized density is being used at this time also ICNTMX is the maximum ICNTX(N)

2. "INSTRUMENT LOG (AVE DENSITY)"
   Calculated for each non-zero class i.e. only if ICNTX(N)>0

   AVEINS(N) = SUMX(N)/ICNTMX
   AVEINSL(N) = LOG (AVEINS(N))

3. "EXPONENTIAL LOG (AVE DENSITY)"
   a. Before this is calculated the True Ave Log Density is determined for each class where ...

   ICNTX(N) $\geq$ .9(ICNTMX)

note: JJPTS = number of classes where above relation is true

using the equations

   AVETRU(N) = SUMX(N)/ICNTX(N)
   AVETRUL(N) = LOG (AVETRU(N))

   b. The set of data points (DIAM(N),AVETRUL(N)) for ICNTX(N) > 0 are linearly curvefit

note: IIPTS = number of classes where above relation is true

   c. The slope (m) and intercept (b) are printed and expressed exponentially to satisfy the equation ...

2.1.3.4 Density spectra (cont'd)

$$N/M^3\text{-mm} = N_o e^{\lambda D}$$

where $N_o = e^{2.3026(b)}$

and $\lambda = 2.3026(m)$

d. The exponential Log (AVE DENSITY) is calculated and plotted for the full spectrum (classes 1-15)

using ...

$$\text{AVEEXP(N)} = N_o e^{\lambda * \text{DIAM(N)}}$$

AVEEXPL(N) = LOG(AVEEXP(N))

where DIAM(N) = center diameter of class N

AVEEXPL(N) is printed only for classes where ICNTX(N) > 0.

2.1.3.4 Density spectra (cont'd)

4. "INSTRUMENT MASS AND REFLECTIVITY"

a. INSTRUMENT MASS

Calculated individually for each class where ICNTX(N)>0 using the instrument average density (AVEINS)

$$MINST(N) = \frac{\pi}{6} BW(N)*AVEINS(N)*DIAM(N)^3$$

where BW(N) = barwidth of class N

Also the cumulative instrument mass is calculated as

$$TMI = \sum_{N=1}^{IIPTS} MINST(N)$$

b. INSTRUMENT REFLECTIVITY

Calculated individually for each class where ICNTX(N)>0 using the instrument average density (AVEINS)

$$ZINST(N) = BW(N)*AVEINS(N)*DIAM(N)^6$$

Also the cumulative instrument reflectivity is calculated as

$$TZI = \sum_{N=1}^{IIPTS} ZINST(N)$$

2.1.3.4 Density spectra (cont'd)

5. "EXPONENTIAL MASS AND REFLECTIVITY"

a. EXPONENTIAL MASS

Calculated individually for each class where ICNTX(N)>0 using the exponential average density (AVEEXP)

$$MEXP(N) = \frac{\pi}{6}BW(N)*AVEEXP(N)*DIAM(N)^3$$

Also the cumulative instrument mass is calculated as

$$TME = \sum_{N=1}^{IIPTS} MEXP(N)$$

b. EXPONENTIAL REFLECTIVITY

Calculated individually for each class where ICNTX(N)>0 using the exponential average density (AVEEXP)

$$ZEXP(N) = BW(N)*AVEEXP(N)*DIAM(N)^6$$

Also the cumulative instrument reflectivity is calculated as

$$TZE = \sum_{N=1}^{IIPTS} ZEXP(N)$$

2.1.3.4 Density spectra (cont'd)

6. "CUMULATIVE PERCENT MASS"

$$\mathrm{CUMASS(N)} = \mathrm{MINST(N)/TMI+TMASS(N-1)}$$

where

$$(\mathrm{TMASS(N-1)} = \sum_{i=1}^{N-1} \mathrm{CUMASS(i)}$$

7. "TOTAL MASS"

To account for integration from D_i to ∞ rather than from 0 to ∞, the equation from SAMS #2 p 58*is modified.

$$\mathrm{MTT} = M_{(>D_1)} = \frac{\pi}{6} N_o \int_{D_1}^{\infty} D^3 e^{-\lambda D} dD$$

$$\mathrm{MTT} = \frac{\pi}{6} N_o e^{-\lambda D_1} \left[\frac{D_1{}^3}{\lambda} + \frac{3D_1{}^2}{\lambda^2} + \frac{6D_1}{\lambda^3} + \frac{6}{\lambda^4} \right]$$

letting

$$\mathrm{NTT} = \frac{N_o e^{-\lambda D_1}}{|\lambda|}$$

, since the slope λ should always be positive

the final equation becomes

$$\mathrm{MTT} = \frac{\pi}{6} \mathrm{NTT} \left[D_1{}^3 + \frac{D_1{}^2}{|\lambda|} + \frac{D_1}{|\lambda|^2} + \frac{6}{|\lambda|^3} \right]$$

If $D_1 = 0$ it can be seen that the equation is identical to that from SAMS #2 p 58*

$$\mathrm{MT} = \frac{\pi N_o}{|\lambda|^4}$$

2.1.3.4 Density spectra (cont'd)

8. "TOTAL REFLECTIVITY"

To account for integration from D_1 to ∞ rather than from 0 to ∞, the equation from SAMS #2 p 58* is modified.

$$ZTT = Z_{(>D_1)} = N_o \int_{D_1}^{\infty} D^6 e^{-\lambda D} dD$$

$$ZTT = N_o e^{-\lambda D_1} \left[\frac{D_1{}^6}{\lambda} + \frac{6D_1{}^5}{\lambda^2} + \frac{30D_1{}^4}{\lambda^3} + \frac{120D_1{}^3}{\lambda^4} + \ldots \right.$$

$$\left. \frac{360D_1{}^2}{\lambda^5} + \frac{720D_1}{\lambda^6} + \frac{720}{\lambda^7} \right]$$

letting

$$NTT = \frac{N_o e^{-\lambda D_1}}{|\lambda|}$$

the final equation becomes

$$ZTT = NTT \left[D_1{}^6 + \frac{6D_1{}^5}{|\lambda|} + \frac{30D_1{}^4}{|\lambda|^2} + \frac{120D_1{}^3}{|\lambda|^3} + \frac{360D_1{}^2}{|\lambda|^4} + \frac{720D_1}{|\lambda|^5} + \frac{720}{|\lambda|^6} \right]$$

If $D_1 = 0$ this equation also reduces to that from SAMS #2 p 58*

$$ZT = \frac{720N_o}{|\lambda|^7}$$

9. "MEDIAN VOLUME DIAMETER"

(from SAMS #2 p 62)*

$$D_o = 3.67/|\lambda|$$

2.1.3.4 Density spectra (cont'd)

10. When the particle type being analyzed is rain only the total mass and total reflectivity should be integrated from D_1 to 5 mm only. This is accomplished by subtracting the 5 mm to infinity value from the D_1 to infinity value for M and Z.

a. "MASS CONSIDERATION"

$$MTT = \frac{\pi}{6} N_o \int_{D_1}^{5} D^3 e^{-\lambda D} dD = \frac{\pi}{6} N_o \left\{ \int_{D_1}^{\infty} D^3 e^{-\lambda D} dD - \int_{5}^{\infty} D^3 e^{-\lambda D} dD \right\}$$

from step 7 the D_1 to ∞ evaluation is

$$e^{-\lambda D_1}\left[\frac{D_1^3}{\lambda} + \frac{3D_1^2}{\lambda^2} + \frac{6D_1}{\lambda^3} + \frac{6}{\lambda^4}\right] = e^{-\lambda D_1} \text{ [LODM]}$$

using the same analysis the 5 mm to ∞ evaluation is

$$e^{-5\lambda} \left[\frac{5^3}{\lambda} + \frac{3 \cdot 5^2}{\lambda^2} + \frac{6 \cdot 5}{\lambda^3} + \frac{6}{\lambda^4}\right] = e^{-5\lambda} \text{ [UPDM]}$$

and finally

$$MTT_{(D_1:5)} = \frac{\pi}{6} N_o \left\{ e^{-\lambda D_1} (\text{LODM}) - e^{-5\lambda} (\text{UPDM}) \right\}$$

b. "REFLECTIVITY CONSIDERATION"

Repeating the previous analysis for reflectivity the final equation becomes

2.1.3.4 Density spectra (cont'd)

$$ZTT_{(D_1:5)} = N_o \left\{ e^{-\lambda D_1}(LODZ) - e^{-5\lambda}(UPDZ) \right\}$$

NTT

For parallelism NTT may be defined as:

$$NTT = N_o \left\{ e^{-\lambda D_1} - e^{-5\lambda} \right\} / \lambda$$

* Hydrometer Parameters Determined from the RADAR DATA of the SAMS Rain Erosion Program; Plank, V. G. (1974).

2.1.3.5 Median volume diameter plots

This option produces three different sets of scatter type plots. A set consists of two plots, each done the same way only using different data; the first plot uses precip data only and the second uses precip data combined with cloud data. The three sets are described in the following pages.

D_o vs $(Z/M)^{1/3}$

For each averaging interval this plot calculates the ratio of reflectivity to mass, and then takes its cube root. This value is checked to insure it is within the horizontal axis limits of 10^{-1} and 10^{+1}. The median volume diameter, for the same interval, is checked to insure it is within the vertical axis limits of 10^{-1} and 10^{+1}.

After the data is plotted, a least square logarithmic fit is calculated and drawn through the data. The equation of this line is included on the plot in the form

$$D_o = a((Z/M)^{1/3})^b$$

The plot output listing includes the equation coefficients (both linear and exponential), the average $(Z/M)^{1/3}$ and D_o values, and their standard deviations.

2.1.3.5 Median volume diameter plots (cont'd)

D_o vs $M/(Z)^{\frac{1}{2}}$

This plot is similar to the one previously discussed the only difference being the x-variable calculation. Here the ratio of mass to square root of reflectivity is calculated. The remaining calculatons, axis scales, and output are the same as the previous plot.

$ND_o{}^4/M$ vs D/D_o

The procedure is a "follow-up" to the data modification technique shown in section 6.3.1.9. This plot differs from the previous two in that it uses every non-zero channel within an averaging interval. That is, for each averaging interval as many as 15 points may be plotted. (If Cloud and Precip data are being used, then there may be as many as 30 points plotted per averaging interval.)

The points are plotted in the following manner. For each averaging interval the 15 (or 30) class diameters are divided by the median volume diameter. These become the x-coordinates of the plotted points. The y-coordinate is determined by multiplying the number density of each class times the fourth power of the median volume diameter. This product is then divided by the calculated mass of the interval. If the density is zero, there is, of course, no point plotted. The plot is produced on a semi-log grid, with the x-axis being linear. After all the points are plotted, a least square exponential fit is calculated and drawn through the data. The coefficients of the equation are shown on

2.1.3.5 Median volume diameter plots (cont'd)

ND_o^4/M vs D/D_o (cont'd)

the plot in the form

$$ND_o^4/M = a\ e^{b\ D/D_o}$$

After the plot is produced, the calculations performed are outlined below.

1. Divide the x-axis into 21 bands

2. Each point plotted is categorized by its x-coordinate into one of these bands:
   a. the y-coordinate is accumulated with other values in the same band.
   b. the number of points in each banded is counted.
   c. when all the data has been categorized and summarized, the average y value for each band is determined.

3. The bands with a zero average y value are examined. This zero results because of one of two conditions:
   a. it may be that a particular band had no points (these are called "uncounted" or type 1 zeroes).
   b. it may be that all the y-coordinate for a particular band were zero (these are called "counted" or type 2 zeroes).

4. Each type of zero may appear in two places:
   a. as a surrounded zero (or consecutive zeroes) where they are surrounded by non-zero bands on both sides.
   b. as an ending zero(or consecutive zeroes)

2.1.3.5 Median volume diameter plots (cont'd)

ND_o^4/M vs D/D_o (cont'd)

The following examples show both cases.

example A. surrounded zero

band#	average y	
2	1.24	
3	0	surrounded zero
4	3.94	
5	0	surrounded zeroes
6	0	
7	1.85	

example B. ending zero

band#	average y	
1	0	ending zero
2	1.24	
3	3.28	
.		
.		
.		
18	1.29	
19	0	
20	0	ending zeroes
21	0	

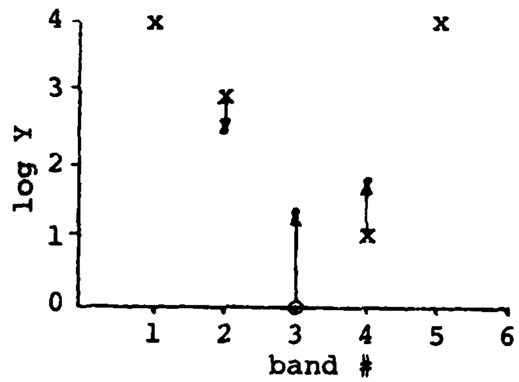
5. An attempt is made to eliminate all the zeroes. The elimination technique used is dependent upon the type (1 or 2) and place (ending or surrounded) of zero. The hierarchy and technique used to eliminate these zeroes is shown on the following page.

2.1.3.5 Median volume diameter plots (cont'd)

$ND_o{}^4/M$ vs D/D_o (cont'd)

	zero (type and place)	technique
1)	#2 surrounded	3 point running log mean
2)	#2 ending	extrapolation
3)	#1 ending	extrapolation
4)	#1 surrounded	interpolation

a. Type 2 surrounded zeroes are removed using a three point running log mean; this changes the surrounding non-zero points also.

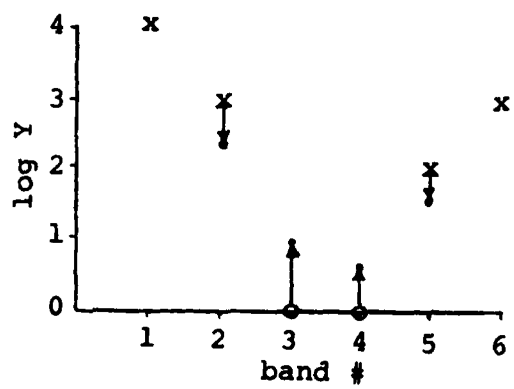


$$y_2' = (y_1+y_2+y_3)/3 = 7/3 = 2\ 1/3$$

$$y_3' = (y_2+y_3+y_4)/3 = 4/3 = 1\ 1/3$$

$$y_4' = (y_3+y_4+y_5)/3 = 5/3 = 1\ 2/3$$

o = zero point x = non-zero point



$$y_2' = (y_1+y_2+y_3)/3 = 7/3 = 2\ 1/3$$

$$y_3' = (y_2+y_3+y_4)/3 = 3/3 = 1$$

$$y_4' = (y_3+y_4+y_5)/3 = 2/3$$

$$y_5' = (y_4+y_5+y_6)/3 = 5/3 = 1\ 2/3$$

Figure 2.11 Examples of type 2 surrounded zero elimination

2.1.3.5 Median volume diameter plots (cont'd)

ND_o^4/M vs D/D_o (cont'd)

b. Ending zeroes of types 1 and 2 are eliminated by extrapolating from the equation

$$y = ce^{[ax^2 + bx]}$$

The equation is a least square fit of four non-zero points immediately preceding or following the zeroes to be eliminated.

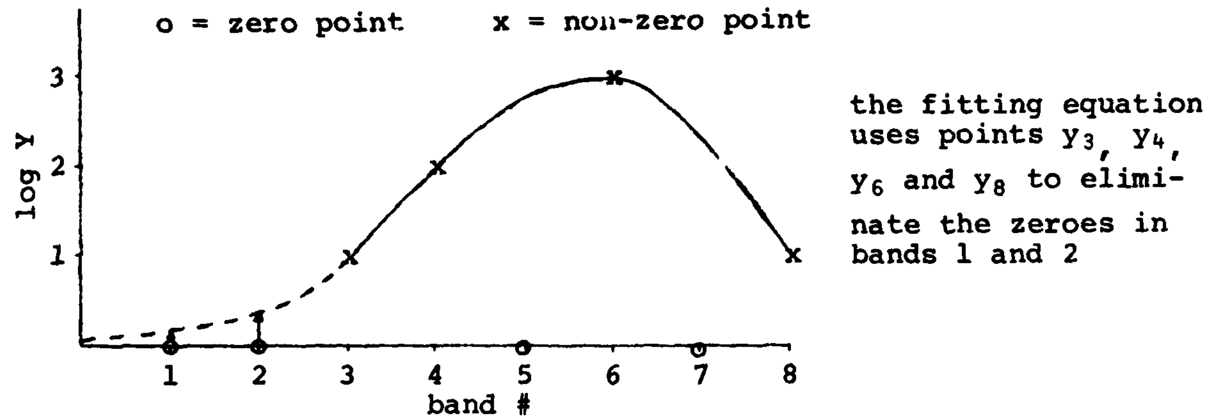


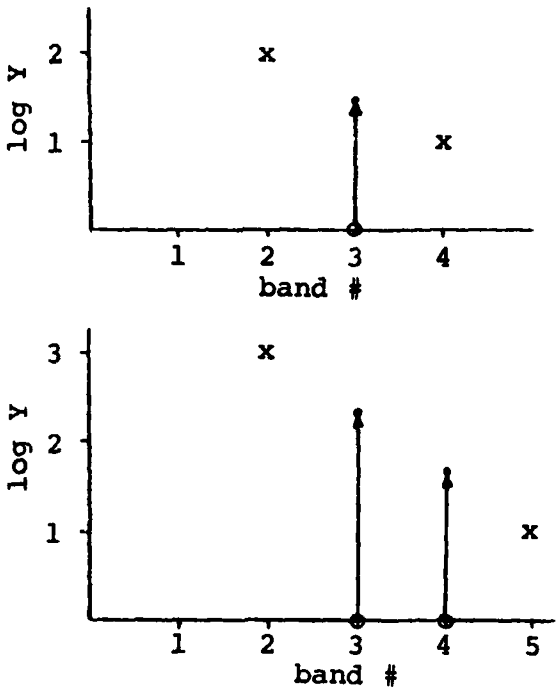
Figure 2.12 Example of ending zero elimination

Zeroes at the other end are eliminated exactly the same way using the four non-zero points preceding the zeroes to be eliminated.

c. Type 1 surrounded zeroes are removed using linear interpolation between adjacent non-zero values.

2.1.3.5 Median volume diameter plots (cont'd)

ND_o^4/M vs D/D_o (cont'd)



$$y_3' = y_2 + \left(\frac{y_4 - y_2}{x_4 - x_2}\right)(x_3 - x_2)$$

$$y_3' = 2 + \left(\frac{1-2}{2}\right)(3-2)$$

$$y_3' = 2 - \tfrac{1}{2} = 1\tfrac{1}{2}$$

o = zero point x = non-zero point

$$y_3' = y_2 + \left(\frac{y_5 - y_2}{x_5 - x_2}\right)(x_3 - x_2)$$

$$y_3' = 3 + \left(\frac{1-3}{5-2}\right)(3-2)$$

$$y_3' = 3 - \left(\frac{2}{3}\right)1 = 2\ 1/3$$

$$y_4' = y_2 + \left(\frac{y_5 - y_2}{x_5 - x_2}\right)(x_4 - x_2)$$

$$y_4' = 3 - \left(\frac{2}{3}\right)2 = 1\ 2/3$$

Figure 2.13 Examples of type 1 surrounded zero elimination

6. After the zeroes have been eliminated the results are shown in the output listing. The bands that had a zero average eliminated are flagged with a 1 or 2 indicating the type zero removed.

2.1.3.6 VCO plots

This option will plot any VCO versus any other VCO. With this option only, the calculated liquid water content (M) and calculated reflectivity (Z) for each probe are considered VCOs. This allows selected Z vs height or M vs height profiles to be plotted. The user has complete freedom to specify any VCO on either axis. Plots may be either in scatter mode or line mode, at the user's option.

If the plot of JW-LWC vs HEIGHT is specified, an adjustment option is available. This adjustment allows for all the data points to be shifted by some reference equation. To invoke this option certain adjustment parameters are necessary. These parameters are:

L = number of levels
XJ = origin of level
SL = slope of level
HT = height (meters)

This information is input via a namelist card. The operating instructions show the details. The adjustment performed follows.

2.1.3.6 VCO plots (cont'd)

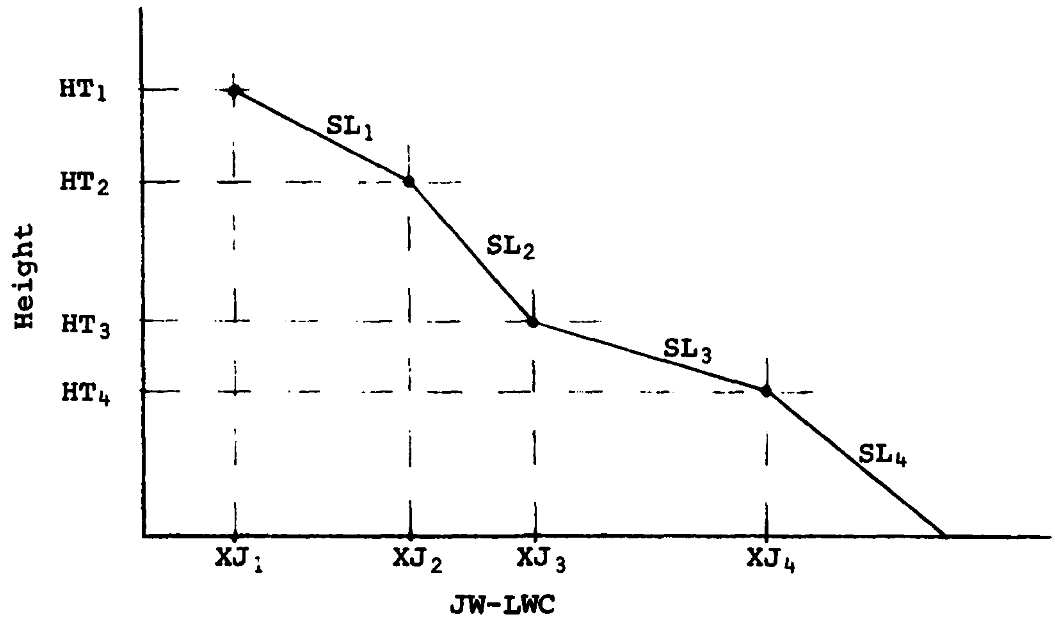


Figure 2.14 JW-LWC vs height adjustment

Determine the level (I) of each data point (J,H) such that $HT_{I+1} > H > HT_I$. Calculate the adjusted water content (JW) using the equation

$$JW = J-[XJ_I + SL_I\ (HT_I-H)]$$

Note: if height (H) is greater than the maximum height (HT_1), than HT_1 is used in the equation for HT_I. The sign reversal will account for the correct JW adjustment.

2.1.3.7 Program KNPLT1D operating instructions

CONTROL CARD

```
JOBNR,CM100000,T600,NT1,PK.              PROB. NO.        NAME
REQUEST, TAPE39,*Q.
DISPOSE,TAPE39,*FM.
PAUSE. PLS PUT WT NUMBERS IN DAYFILE
PAUSE. PLS MOUNT DISK LYCPFI
MOUNT,SN=LYCPFI,VSN=LYCPFI.
ATTACH,CRT,CRTPLOTS.
SETNAME(LYCPFI)
LIBRARY(CRT)
REQUEST,TAPE2,NT,E,VSN=LYCXXX,NORING.   (FROM KNOLL1D)
ATTACH,KP,KNPLT1D,ID=GLASS,MR=1.
ATTACH,P0,PLOTLIB0,ID=GLASS,MR=1.
ATTACH,P1,PLOTLIB1,ID=GLASS,MR=1.
ATTACH,P3,PLOTLIB3,ID=GLASS,MR=1.
ATTACH,P4,PLOTLIB4,ID=GLASS,MR=1.
LDSET,PRESET=ZERO
LOAD(KP,P0,P1,P3,P4)
EXECUTE.
7/8/9
-DATA CARDS-
6/7/8/9
```

2.1.3.7 Program KNPLT1D operating instructions (cont'd)

Data Cards

The first data card is the information card; it appears only once.

Each plot type requires a plot request card. These request cards are unlimited and have the same format. The cards are divided into 16 fields. Each plot type requires certain fields to be used; all the unused fields may be left blank.

card 1. information card

VAR	cc	FORMAT	FUNCTION
PLT	1-3	A3	plot type: PEN or CRT
CLK	5	I1	clock: 1=A/C 2=PMS
IOUT	7	I1	0 = summary only 1 = date & summary
FLID	11-20	A10	flight id: FLT XYR-NN
	21-30	A10	date: DD MON YR
OPT	45	I1	0 = standard data 1 = LEARJET data
INT	49-50	I2	averaging interval (OPT = 1 only)

cards 2...n plot request cards

cc	FORMAT	FUNCTION
1	I1	field 1
3	I1	field 2
5-10	I6	field 3
15-20	I6	field 4
22-25	I4	field 5

2.1.3.7 Program KNPLT1D operating instructions (cont'd)

CC	FORMAT	FUNCTION
27-30	I4	field 6
32-35	I4	field 7
37-40	I4	field 8
42-45	I4	field 9
47-50	I4	field 10
52-55	I4	field 11
57-60	I4	field 12
62-65	I4	field 13
67-70	I4	field 14
72-75	I4	field 15
77-80	I4	field 16

Cards 2 through n may appear in any sequence, however, considerable time is saved if cards with same time limits are consecutive.

The following page, "Request card summary" shows the required fields for each plot type.

REQUEST CARD SUMMARY

FIELD	cc	SCATTER	MZHIST	VCOHIST	SPECTRA	DO	VCOPLOT
1	1	1	2	3	4	5	6
2	3				probe		number
3	5-10	start	start	start	start	start	start
4	15-20	stop	dur	dur	stop	stop	stop
5	22-25	pass	pass		min }bl	pass	h axis code
6	27-30	htkm	htkm		max	htkm	v axis code
7	32-35	minLWC*	minLWC*		min }br	minLWC*	type code
8	37-40	minEXP	minEXP		max	minEXP	h axis code **
9	42-45	maxLWC	maxLWC		min }ml	maxLWC	v axis code **
10	47-50	maxEXP	maxEXP		max	maxEXP	type code
11	52055				min }mr		h axis code
12	57-60				max		v axis code
13	62-65				min }tl		type code
14	67-70				max		h axis code
15	72-75				min }tr		v axis code
16	77-80				max		type code

start = start time (hhmmss)
stop = stop time (hhmmss)
dur = duration in seconds
pass = pass number
htkm = height (km)·10
i.e. 6.5 km = 65
probe = 1; scatter

probe = 2; cloud
probe = 3; precip
number = number of plots (max=4)
min, max = LWC limits
bl, br = bottom left, bottom right
ml, mr = middle left, middle right
tl, tr = top left, top right
* minLWC,EXP = minimum acceptable LWC = $(\text{minLWC})\cdot 10^{\text{minEXP}}$
maxLWC,EXP = maximum acceptable LWC = $(\text{maxLWC})\cdot 10^{\text{maxEXP}}$
type ~~code~~ = 1 scatter plot
type code = 2 line plot

** AXIS codes are shown in Appendix 6

2.1.3.7 Program KNPLT1D operating instructions (cont'd)

SCATTER PLOTS

This option produces two plots of LOG M vs. LOG Z. Plot one uses Precip Probe data only and plot two uses total data. A least squares linear fit is drawn through the data. The coefficients appear in the form M = A*Z**B.

INPUT CARD:

field 1	1	
field 3	start time	(HHMMSS)
field 4	stop time	(HHMMSS)
field 5	pass	(rj)
field 6	HTKM*10	(rj)
	i.e. 30 km = 300	
	27.2km = 272	

HISTOGRAMS

This option produces two histograms, the first, LOG M vs. time, and the second, LOG Z vs. time. Each histogram contains three plots, one for each probe. The time axis is set for a 300 second maximum, however, less data may be plotted.

INPUT CARD:

field 1	2	
field 3	start time	(HHMMSS)
field 4	duration seconds	(rj)
field 5	pass	(rj)
field 6	HTKM*10	(rj)

2.1.3.7 Program KNPLT1D operating instructions (cont'd)

VCO's

This option produces three plots with two VCO's per plot. The six VCO's plotted are not variable. They are: Magnetic Heading, LWC(JW), Temperature, Dewpoint, Pressure, and Acceleration. The scales for Acceleration and LWC(JW) are fixed at $\pm$ 1g and -.1 to +.8 gm/m^3 respectively. The remaining VCO's have fixed ranges but the scale slides to plot as many points as possible. The fixed ranges are: Pressure (30 mb), Temperature (12°C), Dewpoint (12°C), and Heading (deg). The time axis is set for a 300 second maximum, however, less data may be plotted.

INPUT CARD:

field 1	3
field 3	start time (HHMMSS)
field 4	duration seconds (rj)

DENSITY SPECTRA

This option produces six plots of number density vs. equivalent melted diameter. Each plot uses only data from the specified probe for six liquid water content bands. The LWC bands are variable but the probe must be the same for all six plots. If the particle type remains constant for the entire interval, an average line is drawn through the data. Also, the cumulative percent mass is superimposed on each plot.

2.1.3.7 Program KNPLT1D operating instructions (cont'd)

INPUT CARD:

field 1	4		
field 2	probe		(1=sc, 2=cl, 3=pr)
field 3	start time		(HHMMSS)
field 4	stop time		(HHMMSS)
field 5	min	BL	rj
field 6	max		rj
field 7	min	BR	rj
field 8	max		rj
field 9	min	ML	rj
field 10	max		rj
field 11	min	MR	rj
field 12	max		rj
field 13	min	TL	rj
field 14	max		rj
field 15	min	TR	rj
field 16	max		rj

The min and max values are the lower and upper limits of each LWC band. The LWC limits are in units of mg/M^3 with the 10^{-3} exponent omitted. Since there are four columns per limit, the absolute range of limits is from $1 = .001\ mg/M^3 = 1\ mg/M^3$ to $9999 \simeq 10.0\ gm/M^3 = 10^4\ mg/M^3$.

The two letter code BL, MR, etc. indicate which plot on the page is used. The plots are oriented as follows:

TL	TR
ML	MR
BL	BR

2.1.3.7 Program KNPLT1D operating instructions (cont'd)

Less than six plots may be utilized by leaving the appropriate columns on the input card blank.

MEDIAN VOLUME DIAMETER

The Median Volume Diameter module produces seven plots of the following form.

D_o vs. $(Z/M)^{1/3}$	Precip only
D_o vs. $(Z/M)^{1/3}$	Cloud & Precip
D_o vs. K	Precip only
D_o vs. K	Cloud & Precip
ND_o^4/M vs. D/D_o	Precip only
ND_o^4/M vs. D/D_o	Cloud only
ND_o^4/M vs. D/D_o	Cloud & Precip

INPUT:

field 1	5	
field 3	start time	(HHMMSS)
field 4	stop time	(HHMMSS)
field 5	pass	(rj)
filed 6	HTKM*10	(rj)

2.1.3.7 Program KNPLT1D operating instructions (cont'd)

VCO PLOT

This module produces a maximum of four plots per input card. The plots are any VCO, LWC, or X versus any other VCO, LWC or Z. There are two types of plotting: scatter or line. This option does not have a 300 point maximum, hence the plots can be run for an entire flight.

In the special case of plotting JW Liquid Water Content vs. Height an additional option is provided. This allows for all the data points to be shifted by some reference equation. The information for this adjustment is on a -$ADJUST card. This card must immediately follow the input card which specifies the JW-LWC vs. HEIGHT plot.

INPUT CARD:

field 1	6		
field 2	# number of plots this card (4 max)		
field 3	start time (HHMMSS)		
field 4	stop time (HHMMSS)		
field 5	horizontal axis		(rj)
field 6	vertical axis	Plot 1	(rj)
field 7	type		(rj)
field 8	horizontal axis		(rj)
field 9	vertical axis	Plot 2	(rj)
field 10	type		(rj)
field 11	horizontal axis		(rj)
field 12	vertical axis	Plot 3	(rj)
field 13	type		(rj)
field 14	horizontal axis		(rj)
field 15	vertical axis	Plot 4	(rj)
field 16	type		(rj)

2.1.3.7 Program KNPLT1D operating instructions (cont'd)

JW-LWC ADJUSTMENT CARD

If a VCO plot request card specifies a LWC-JW vs. HEIGHT plot, (i.e. h axis code = 5, v axis code = 2, and type code = 0) the next card must contain the adjustment parameters. The required parameters are:

L = number of levels (10 maximum)
XJ = origin of the level
SL = slope of the level
HT = height (meters) at the top of the level

The card uses a standard namelist format with the control variable being $ADJUST. If the option is not desired the card must be

$ADJUST L=0, $END

2.1.3.8 KNPLT1D sample plots

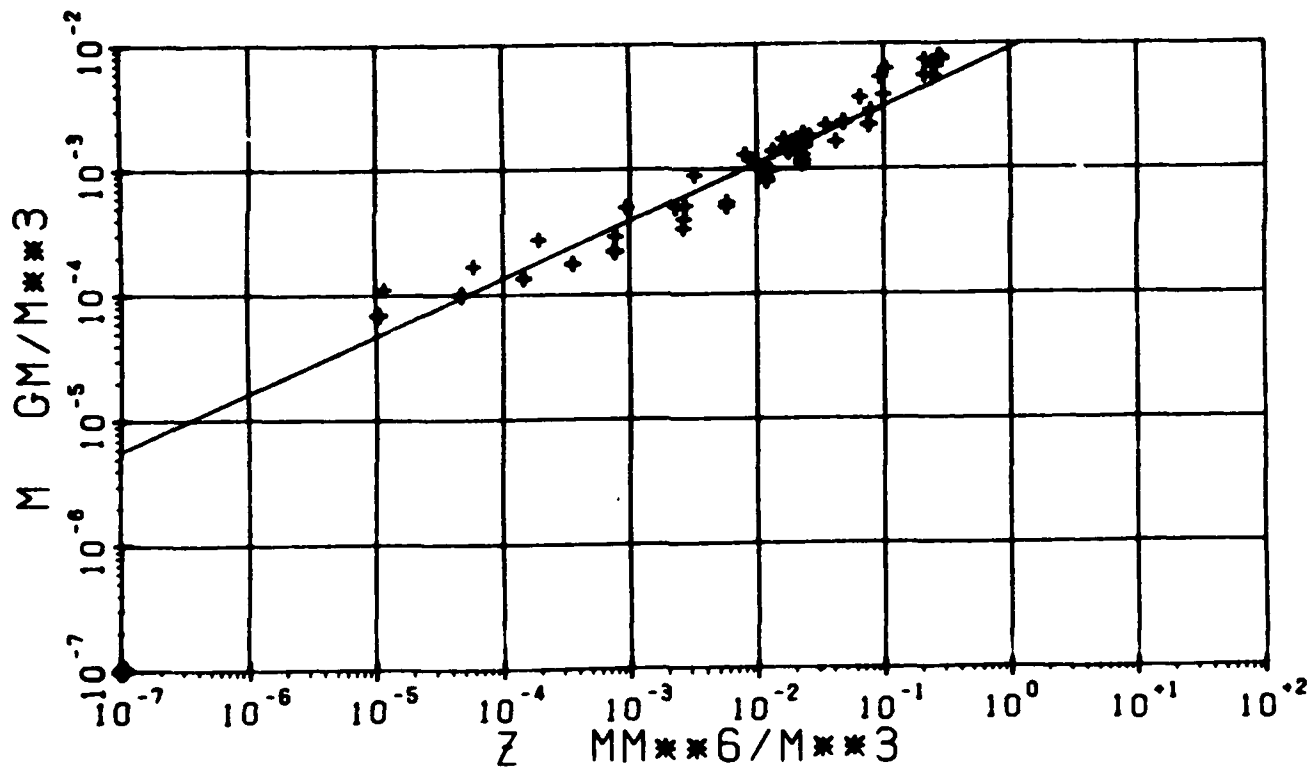
The following pages include KNPLT1D sample plots.

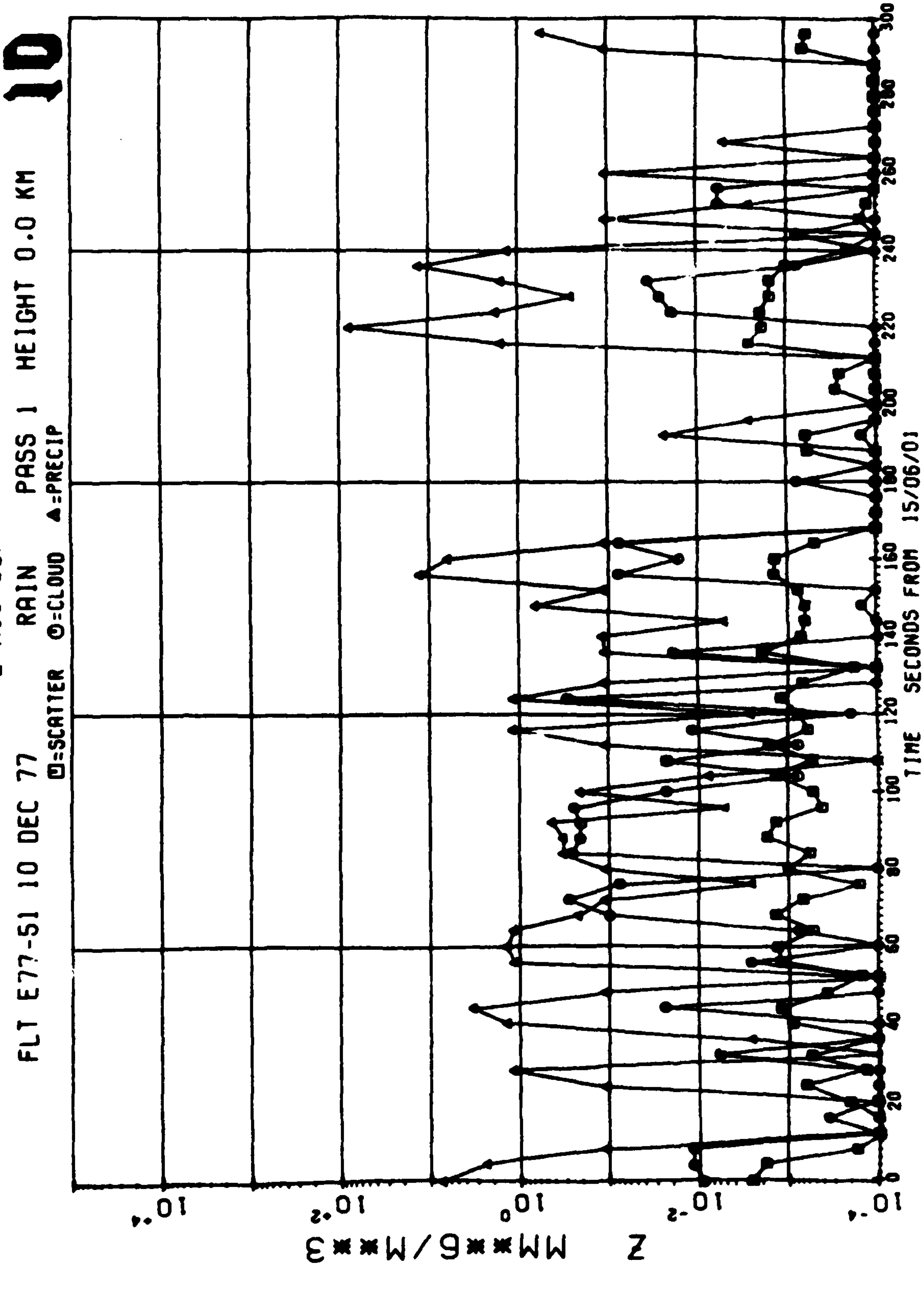
CLOUD M VS Z

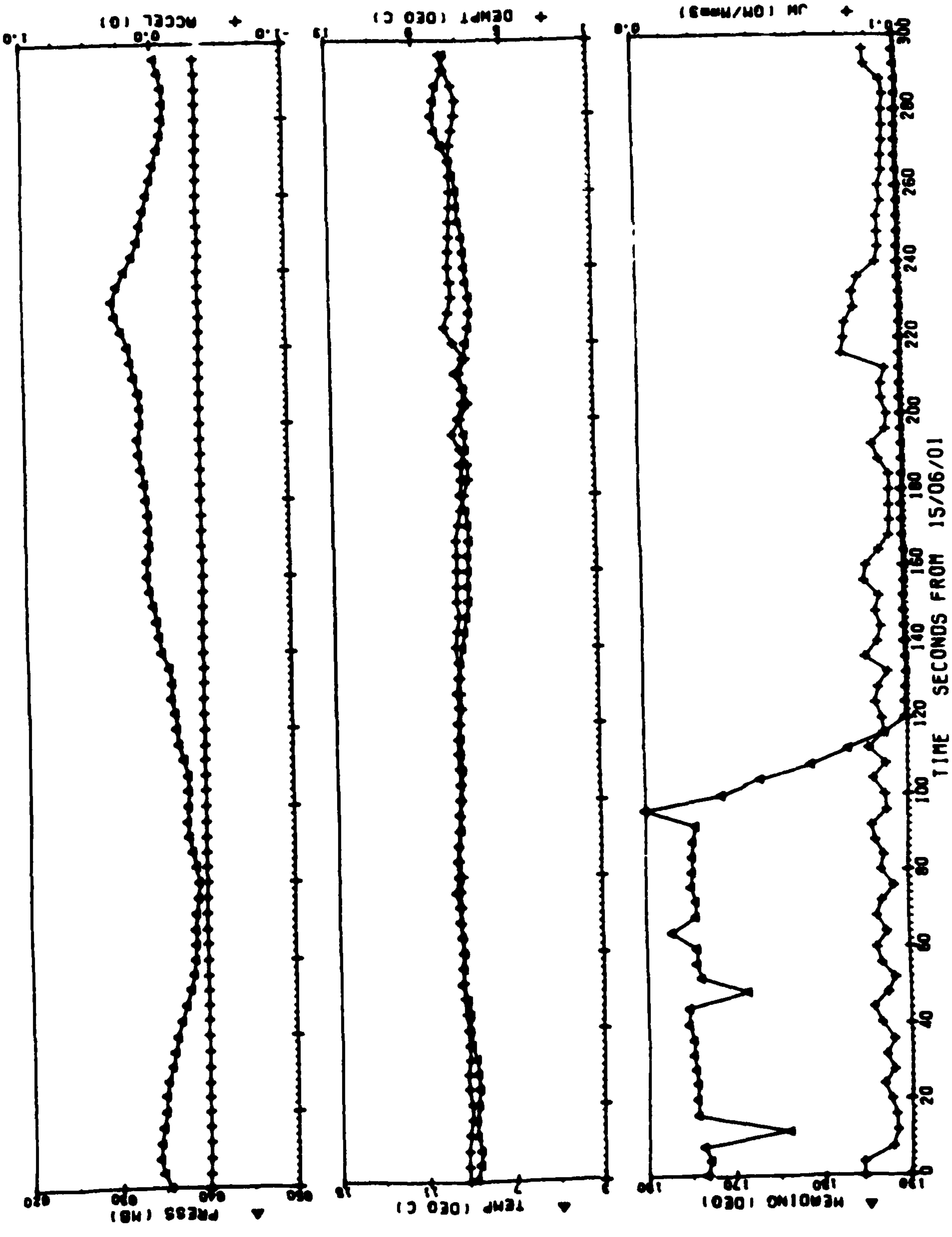
FLT E77-51 10 DEC 77 RAIN **1D**

15/06/00 TO 15/13/00 PASS 1 HEIGHT 0.0 KM

$M=0.0091Z^{0.4582}$

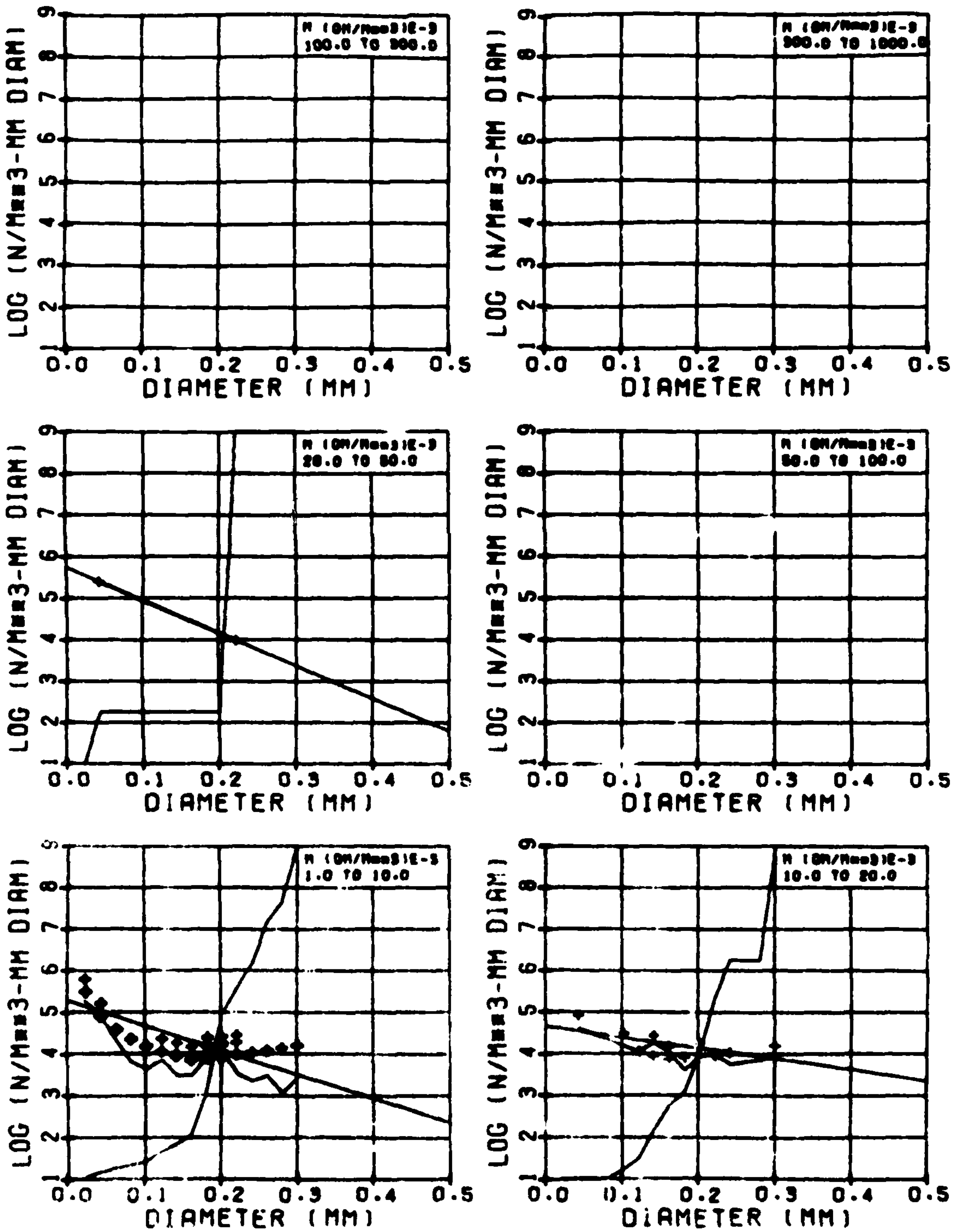



FLT E77-51 10 DEC 77
Z HISTOGRAM
RAIN
PASS 1
HEIGHT 0.0 KM
□=SCATTER ⊙=CLOUD ▲=PRECIP
1D
TIME SECONDS FROM 15/06/01
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Z MM**6/M**3
10^{-4} 10^{-2} 10^{0} 10^{2} 10^{4}


TIME SECONDS FROM 15/06/01

FLT E77-51 10 DEC 77 RAIN

15/06/00 TO 15/13/00 CLOUD PROBE **1D**

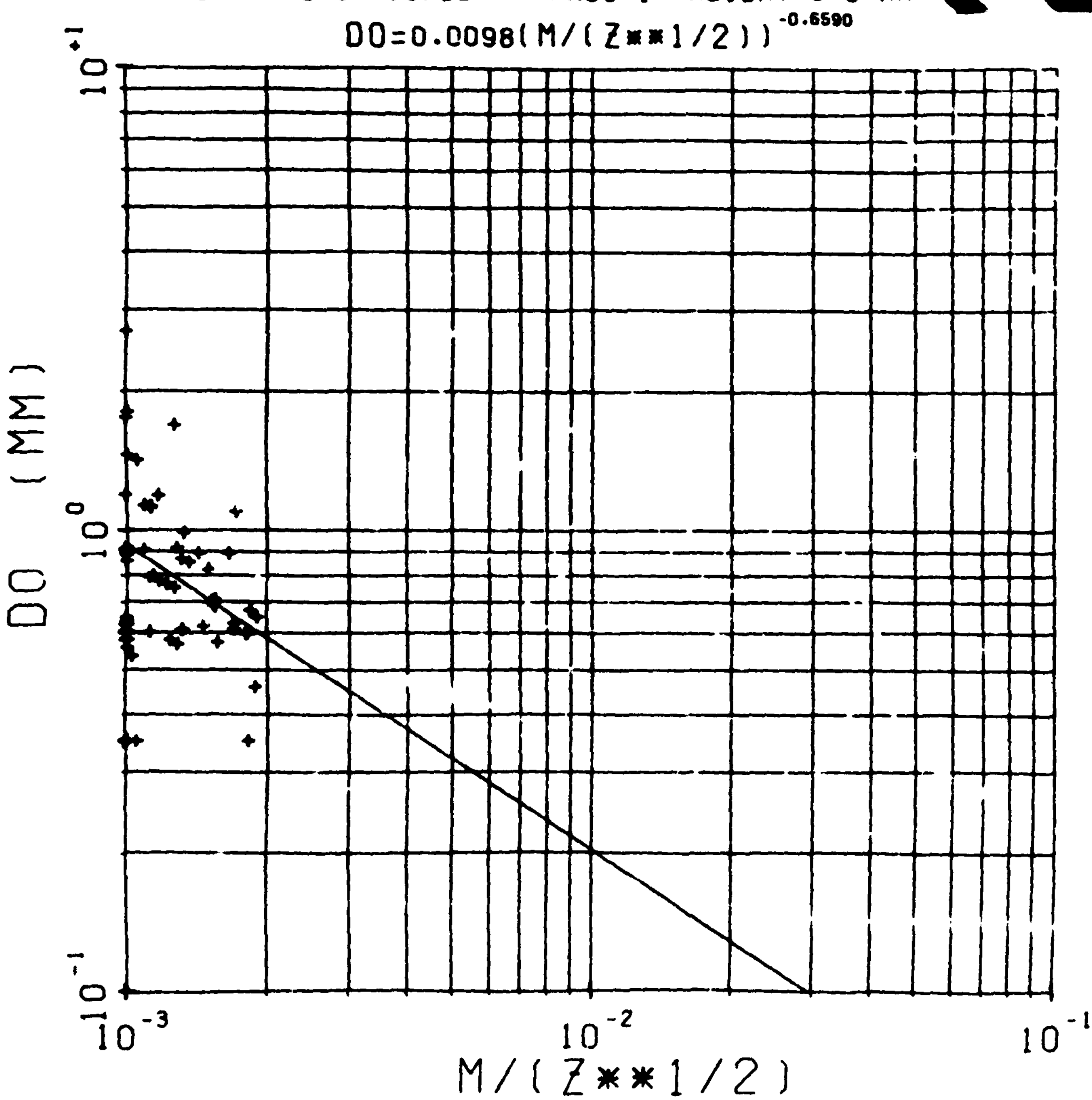


PRECIP DO VS M/(Z**1/2)

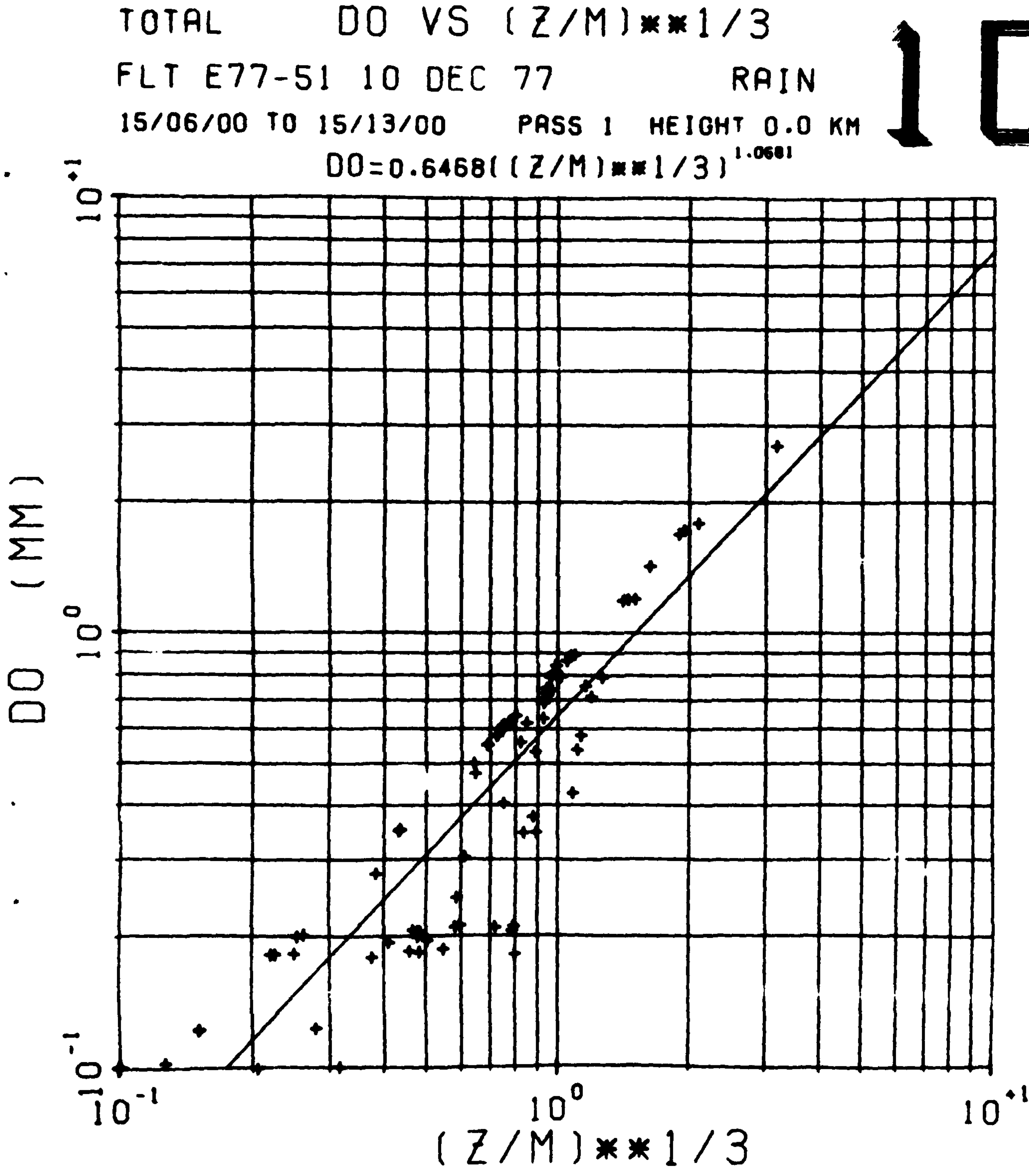
FLT E77-51 10 DEC 77 RAIN

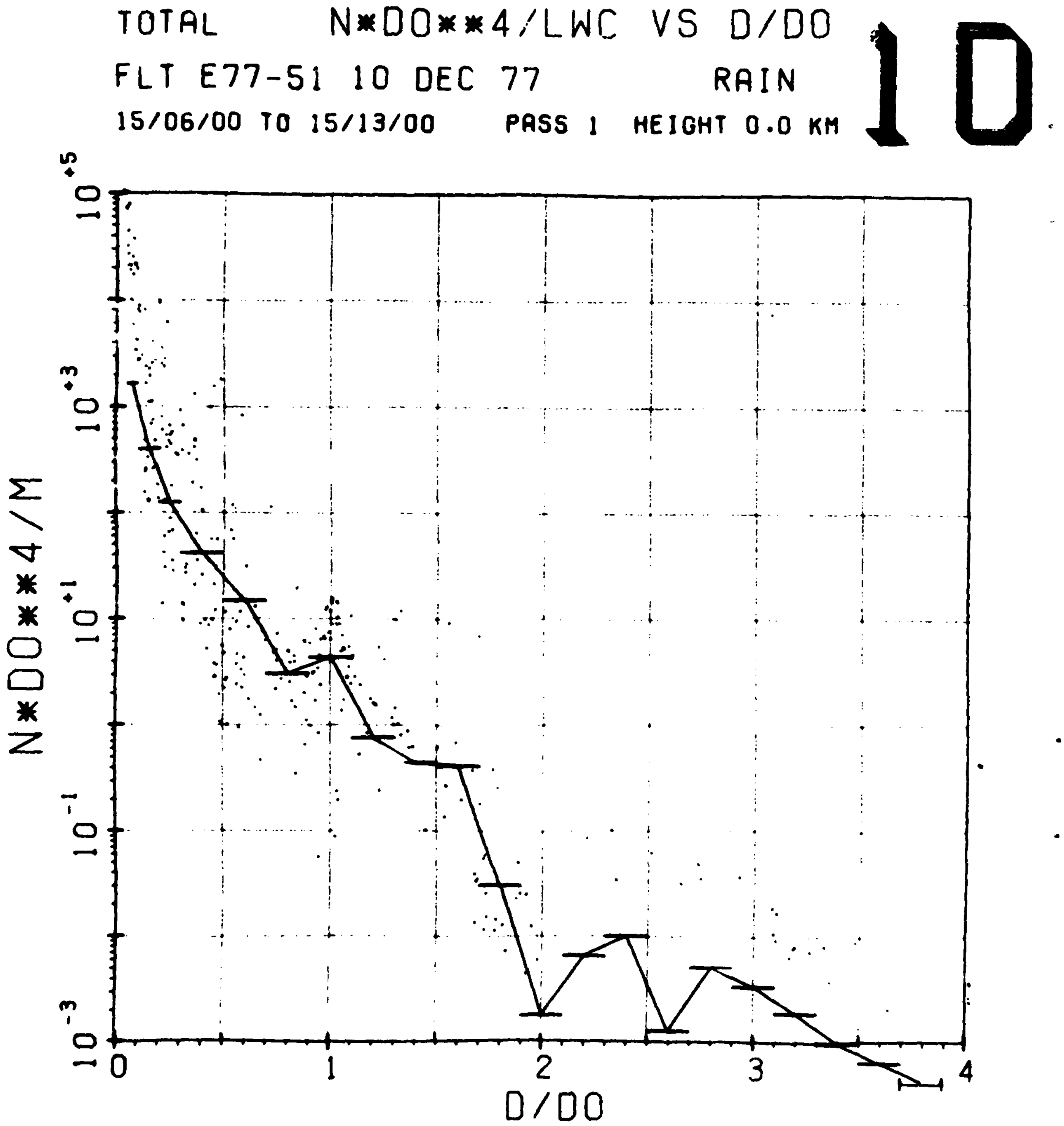
15/06/00 TO 15/13/00 PASS 1 HEIGHT 0.0 KM

1D



1D


TOTAL DO VS (Z/M)**1/3
FLT E77-51 10 DEC 77 RAIN
15/06/00 TO 15/13/00 PASS 1 HEIGHT 0.0 KM
DO=0.6468((Z/M)**1/3)^1.0681
DO (MM)
10^+1
10^0
10^-1
10^-1
10^0
10^+1
(Z/M)**1/3

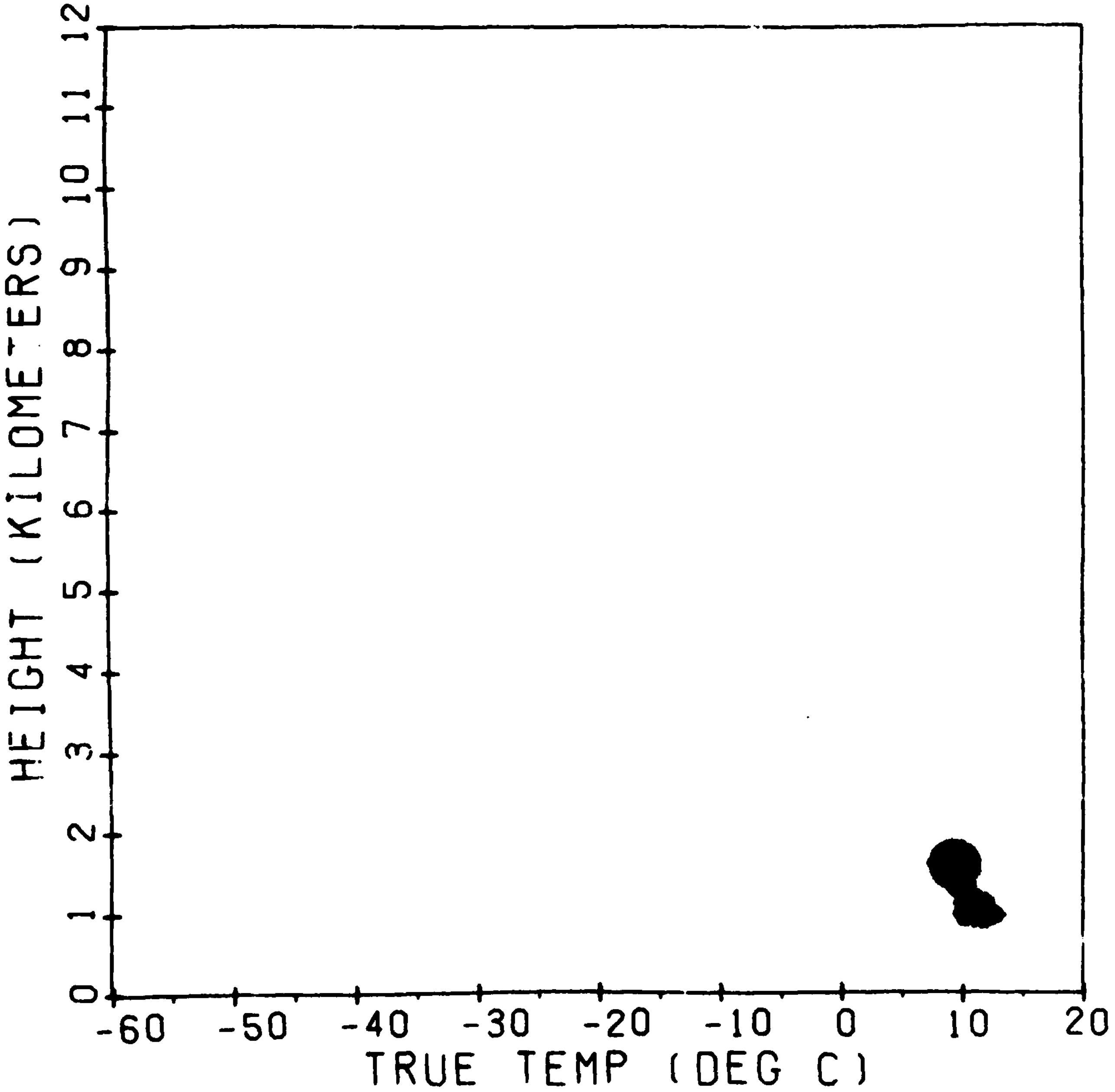

TOTAL N*DO**4/LWC VS D/DO
FLT E77-51 10 DEC 77 RAIN
15/06/00 TO 15/13/00 PASS 1 HEIGHT 0.0 KM
1D
N*DO**4/M
10^+5
10^+3
10^+1
10^-1
10^-3
0
1
2
3
4
D/DO

HEIGHT VS TRUE TEMP

FLT E77-51 10 DEC 77

15/06/00 TO 15/53/00

1D

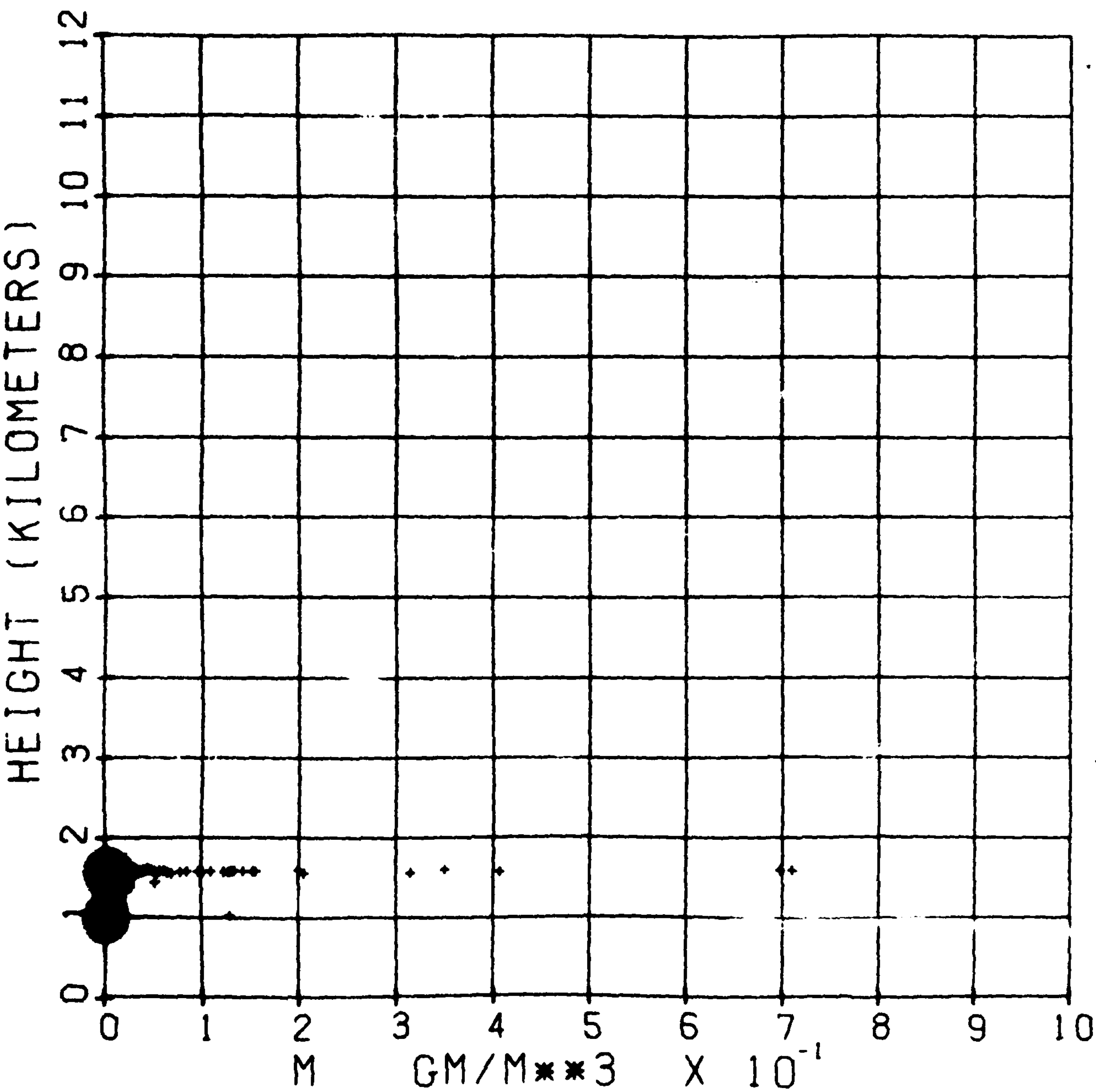


HEIGHT VS LWC(PREC)

FLT E77-51 10 DEC 77

15/06/00 TO 15/53/00

1D



2.1.3.9 KNPLT1D sample outputs

The following pages show sample outputs of program KNPLT1D.

```
    1   DDDDDDD    PPPPPPP   LL          OOOOOO   TTTTTTTTTT   SSSSSS
   11   DDDDDDDD   PPPPPPPP  LL         OOOOOOOO  TTTTTTTTTT  SSSSSSS
  111   DD    DD   PP    PP  LL        OO    OO      TT     SS
 1111   DD    DD   PP    PP  LL        OO    OO      TT     SS
   11   DD    DD   PP    PP  LL        OO    OO      TT     SS
   11   DD    DD   PPPPPPPP  LL        OO    OO      TT      SSSSS
   11   DD    DD   PPPPPPP   LL        OO    OO      TT       SSSSS
   11   DD    DD   PP        LL        OO    OO      TT           SS
   11   DD    DD   PP        LL        OO    OO      TT           SS
   11   DD    DD   PP        LL        OO    OO      TT           SS
 111111 DDDDDDDD   PP        LLLLLLLL  OOOOOOOO      TT     SSSSSSS
 111111 DDDDDDD    PP        LLLLLLLL   OOOOOO       TT     SSSSSS
```

AFGL 1-DIMENSIONAL PARTICLE ANALYSIS PLOTTING PROGRAM
VERSION 2.13.12

FLT E77-51
10 DEC 77
PROCESSED ON 06/22/78
AT 20.50.02

```
PLOT 1  SCATTER
     START:150500   STOP:151300     PASS= 1     HTKM=   0     MINIMUM LWC= 1.000E-10 GRAMS     MAXIMUM LWC= 1.000E+10 GRAMS

     CLOUD   105 POINTS USED

 LEAST SQUARE FIT          Y = ( 4.5825E-01)X + (-2.0418E+00)

                           Y = ( 9.0627E-03)X** ( 4.5325E-01)

 X LOG MEAN= -2.314(4.8543E-03)               Y LOG MEAN= -3.102(7.9047E-04)
 X LOG STD =  1.255(1.9993E+01)               Y LOG STD =   .592(3.9054E+00)

     PRECIP   105 POINTS USED

 LEAST SQUARE FIT          Y = ( 5.2543E-01)X + (-2.9530E+00)

                           Y = ( 1.1144E-03)X** ( 5.2543E-01)

 X LOG MEAN=   .030(1.0796E+00)               Y LOG MEAN= -2.937(1.1561E-03)
 X LOG STD =   .937(7.1243E+00)               Y LOG STD =   .466(2.9226E+00)

     TOTAL   105 POINTS USED

 LEAST SQUARE FIT          Y = ( 3.5731E-01)X + (-2.7249E+00)

                           Y = ( 1.8839E-03)X** ( 3.5731E-01)

 X LOG MEAN=  -.237(5.0415E-01)               Y LOG MEAN= -2.831(1.4749E-03)
 X LOG STD =  1.172(1.4345E+01)               Y LOG STD =   .468(3.0796E+00)
 X LOG MEAN=   .317(2.0773E+00)
```

PLOT 2 HISTOGRAM

START 115353? DURATION= 300 PASS= 1 HTKM= 0 MINIMUM LWC= 1.000E-10 GRAMS MAXIMUM LWC= 1.000E+10 GRAMS

LOG M 75 POINTS USED

LOG M 75 POINTS USED

LOG ? 75 POINTS USED

LOG Z 75 POINTS USED

LOG Z 75 POINTS USED

LOG Z 75 POINTS USED

PLOT 7 VCDIS

START=150510 DURATION= 300 PASS= 1 HTKM= 0

HEADING 75 POINTS USED

UN-LNC 75 POINTS USED

TEMP 75 POINTS USED

DEWPOINT 75 POINTS USED

PRESSURE-K 75 POINTS USED

ACCEL 75 POINTS USED

PLOT 4 DENSITY SPECTRA CLOUD PROBE
START1150500 STOP1151300

MIN	MAX
1	10
10	20
20	50
50	100
100	300
300	1000

LIMITS 1 152 POINTS USED

CLASS	POINTS	DIAM (MM)	CUM PCT MASS	INSTRUMENT LOG(AVE N)	EXPONENTIAL LOG (AVE N)	INSTRUMENT M (MG/M**3)	EXPONENTIAL M (MG/M**3)	INSTRUMENT Z (MM**6/M**3)	EXPONENTIAL Z(MM**6/M**3)
1	12	.023	[illegible]	5.29023	5.12267	2.591E-02	1.752E-02	6.341E-07	4.311E-07
2	21	.047	.022	4.94331	5.00734	7.477E-02	8.501E-02	1.145E-05	1.309E-05
3	1	.067	.033	4.35174	4.89201	6.827E-02	2.022E-01	2.783E-05	9.654E-05
4	7	.087	.044	3.82566	4.77668	3.939E-02	3.519E-01	4.271E-05	3.615E-04
5	7	.103	.055	3.65317	4.66135	5.097E-02	5.134E-01	1.051E-04	1.059E-03
6	11	.122	.085	3.83384	4.54601	1.374E-01	6.594E-01	4.811E-04	2.341E-03
7	7	.142	.106	3.43192	4.43066	9.042E-02	8.035E-01	4.966E-04	4.413E-03
8	9	.162	.137	3.49595	4.31535	1.378E-01	9.111E-01	1.119E-03	7.393E-03
9	10	.182	.263	3.95971	4.20002	5.678E-01	9.373E-01	6.515E-03	1.133E-02
10	24	.202	.493	4.19467	4.09469	1.072E+00	1.032E+00	1.615E-02	1.615E-02
11	5	.221	.574	3.51064	3.96936	3.646E-01	1.049E+00	7.557E-03	2.173E-02
12	5	.241	.647	3.35223	3.85403	3.274E-01	1.040E+00	8.775E-03	2.785E-02
13	6	.261	.772	3.49261	3.73870	5.690E-01	1.010E+00	1.902E-02	3.429E-02
14	2	.281	.831	3.06352	3.62337	2.657E-01	9.543E-01	1.123E-02	4.075E-02
15	4	.301	1.000	3.43147	3.50804	7.605E-01	9.071E-01	3.945E-02	4.706E-02
SUMMATION						4.493E+00	1.054E+01	1.110E-01	2.149E-01

BEST FIT EQUATION N/M**3-MM = N0*EXP**(LAMBDA*D): N0= 1.815E+05 SLOPE= -5.62
(15 CLASSES) LAMBDA= -13.41203 INTERCEPT= 5.26

MTT= 1.752E+01 ZTT= 1.674E+00 NTT= 1.129E+04
MI(T)/MTT= 2.564E-01 ZI(T)/ZTT= 6.623E-02 D0= .274
ME(T)/MTT= 5.992E-01 ZE(T)/ZTT= 1.284E-01 MAX COUNT= 24 2 CLASSES WITH 80 PERCENT MINIMUM(

LIMITS 2 14 POINTS USED

CLASS	POINTS	DIAM (MM)	CUM PCT MASS	INSTRUMENT LOG(AVE N)	EXPONENTIAL LOG (AVE N)	INSTRUMENT M (MG/M**3)	EXPONENTIAL M (MG/M**3)	INSTRUMENT Z (MM**6/M**3)	EXPONENTIAL Z(MM**6/M**3)
1	0	.023	0.000		4.50083	0.	5.293E-03	0.	1.297E-07
2	1	.043	.005	4.61355	4.54966	3.433E-02	2.363E-02	5.206E-06	4.563E-06
3	0	.067	.005		4.49848	0.	5.153E-02	0.	3.901E-05
4	0	.087	.005		4.44731	0.	1.548E-01	0.	1.787E-04
5	1	.107	.032	4.10323	4.39613	1.747E-01	2.733E-01	3.604E-04	5.753E-04
6	2	.127	.055	4.05290	4.34495	2.127E-01	4.207E-01	7.696E-04	1.473E-03
7	2	.142	.1[illegible]	4.25109	4.29378	5.425E-01	5.953E-01	2.979E-03	3.220E-03

SUMMATION						5.631E+00	1.337E+01	1.849E-01	3.687E-01

BEST FIT EQUATION N/M**3-MM = N0*EXP**(LAMBDA*D) ; N0= 4.565E+04 SLOPE= -2.58
(10 CLASSES) LAMBDA= -5.95138 INTERCEPT= 4.66

MTT= 1.14.E+02 ZTT= 1.248E+02 NTT= 7.109E+03
MI(T)/MTT= 5.776E-02 ZI(T)/ZTT= 1.41E-03 D0= .617
ME(T)/MTT= 1.153E-01 ZE(T)/ZTT= 2.934E-03 MAX COUNT= 2 10 CLASSES WITH 80 PERCENT MINIMUM(1)

LIMITS 3 2 POINTS USED

CLASS	POINTS	DIAM (MM)	CUM PCT MASS	INSTRUMENT LOG(AVE N)	EXPONENTIAL LOG (AVE N)	INSTRUMENT M (MG/M**3)	EXPONENTIAL M (MG/M**3)	INSTRUMENT Z (MM**6/M**3)	EXPONENTIAL Z(MM**6/M**3)
1	0	.023	0.000		5.54771	0.	4.558E-02	0.	1.147E-06
2	1	.043	.158	5.39165	5.39171	2.050E-01	2.050E-01	3.171E-05	3.172E-05
3	0	.063	.158		5.23571	0.	4.451E-01	0.	2.130E-04
4	0	.083	.158		5.07971	0.	7.071E-01	0.	7.666E-04
5	0	.103	.158		4.92371	0.	9.333E-01	0.	1.938E-03
6	0	.122	.158		4.76771	0.	1.114E+00	0.	3.900E-03
7	0	.142	.158		4.61171	0.	1.213E+00	0.	6.695E-03
8	0	.162	.158		4.45571	0.	1.253E+00	0.	1.022E-02
9	0	.182	.158		4.29972	0.	1.242E+00	0.	1.425E-02
10	0	.202	.158		4.14372	0.	1.183E+00	0.	1.651E-02
11	1	.221	1.000	3.98769	3.98772	1.094E+00	1.094E+00	2.267E-02	2.267E-02
12	0	.241	1.000		3.83172	0.	9.374E-01	0.	2.646E-02
13	0	.261	1.000		3.67572	0.	8.735E-01	0.	2.966E-02
14	0	.281	1.000		3.51972	0.	7.595E-01	0.	3.212E-02
15	0	.301	1.000		3.36372	0.	6.507E-01	0.	3.375E-02
SUMMATION						1.300E+00	1.273E+01	2.270E-02	2.012E-01

BEST FIT EQUATION N/M**3-MM = N0*EXP**(LAMBDA*D) ; N0= 5.396E+05 SLOPE= -7.88
(2 CLASSES) LAMBDA= -18.14152 INTERCEPT= 5.73

MTT= 1.555E+01 ZTT= 6.007E-01 NTT= 2.323E+06
MI(T)/MTT= 6.385E-02 ZI(T)/ZTT= 3.779E-02 D0= .202
ME(T)/MTT= 8.133E-01 ZE(T)/ZTT= 3.349E-01 MAX COUNT= 1 2 CLASSES WITH 80 PERCENT MINIMUM(1)

PLOT 5 MEDIAN VOLUME DIAMETER
START(151530 STOP(151300) PASS= 1 ITMM= 0 MINIMUM LWC= 1.000E-10 GRAMS MAXIMUM LWC= 1.000E+10 GRAMS

DO V Z/M PRECIP 40 POINTS USED

LEAST SQUARE FIT Y = (-1.0337E+00)X + (-9.1014E-02)

Y = (8.1093E-01)X** (1.0337E+00)

X LOG MEAN= -.355(8.8435E-01) Y LOG MEAN= -.145(7.1141E-01)
X LOG STD = .176(1.4999E+00) Y LOG STD = .167(1.5247E+00)

DO V K PRECIP 40 POINTS USED

LEAST SQUARE FIT Y = (-6.5901E-01)X + (-2.0333E+00)

Y = (9.7745E-03)X** (-6.5901E-01)

X LOG MEAN= -2.853(1.7222E-03) Y LOG MEAN= -.123(7.5259E-01)
X LOG STD = .341(1.2938E+00) Y LOG STD = .142(1.3864E+00)

NOGI V DOD PRECIP

BAND	SAMPLES (ZERO)	D/DO FROM - TO		MID		AVE Y	Y=N*D0**4/M LOG(AVE Y)
1	0 (0)	.030	.100	.070	1	0.	-50.00000
2	0 (0)	.100	.200	.150	1	0.	-50.00000
3	0 (0)	.200	.300	.250	1	0.	-50.00000
4	0 (0)	.300	.500	.400	1	0.	-50.00000
5	0 (0)	.500	.700	.600	1	0.	-50.00000
6	0 (0)	.700	.900	.800	1	0.	-50.00000
7	0 (0)	.900	1.100	1.000	1	0.	-50.00000
8	0 (0)	1.100	1.300	1.200	1	0.	-50.00000
9	0 (0)	1.300	1.500	1.400	1	0.	-50.00000

10	0	(0)	1.500	1.700	1.600	1	0.	-50.00000
11	0	(0)	1.700	1.300	1.300	1	0.	-50.00000
12	0	(0)	1.900	2.100	2.000	1	0.	-50.00000
13	0	(0)	2.100	2.300	2.200	1	0.	-50.00000
14	0	(0)	2.300	2.500	2.400	1	0.	-50.00000
15	0	(0)	2.500	2.700	2.600	1	0.	-50.00000
16	0	(0)	2.700	2.900	2.800	1	0.	-50.00000
17	0	(0)	2.900	3.100	3.000	1	0.	-50.00000
18	0	(0)	3.100	3.300	3.200	1	0.	-50.00000
19	0	(0)	3.300	3.500	3.400	1	0.	-50.00000
20	0	(0)	3.500	3.700	3.600	1	0.	-50.00000
21	0	(0)	3.700	3.900	3.800	1	0.	-50.00000

0 SAMPLES USED   1= UNCOUNTED ZERO
0 SAMPLES IGNORED   2= COUNTED ZERO

N384 V 006 3.0UP

BAND	SAMPLES	(ZEROS)	D/D0 FROM	- TO	MID		AVE-Y	Y=N*D0**4/M LOG(AVE-Y)
1	0	(0)	.050	.100	.075	1	0.	-50.00000
2	0	(0)	.100	.200	.150	1	0.	-50.00000
3	0	(0)	.200	.300	.250	1	0.	-50.00000
4	0	(0)	.300	.500	.400	1	0.	-50.00000
5	0	(0)	.500	.700	.600	1	0.	-50.00000
6	0	(0)	.700	.900	.800	1	0.	-50.00000
7	0	(0)	.900	1.100	1.000	1	0.	-50.00000
8	0	(0)	1.100	1.300	1.200	1	0.	-50.00000
9	0	(0)	1.300	1.500	1.400	1	0.	-50.00000
10	0	(0)	1.500	1.700	1.600	1	0.	-50.00000
11	0	(0)	1.700	1.900	1.800	1	0.	-50.00000
12	0	(0)	1.900	2.100	2.000	1	0.	-50.00000
13	0	(0)	2.100	2.300	2.200	1	0.	-50.00000
14	0	(0)	2.300	2.500	2.400	1	0.	-50.00000
15	0	(0)	2.500	2.700	2.600	1	0.	-50.00000
16	0	(0)	2.700	2.900	2.800	1	0.	-50.00000
17	0	(0)	2.900	3.100	3.000	1	0.	-50.00000
18	0	(0)	3.100	3.300	3.200	1	0.	-50.00000
19	0	(0)	3.300	3.500	3.400	1	0.	-50.00000
20	0	(0)	3.500	3.700	3.600	1	0.	-50.00000
21	0	(0)	3.700	3.900	3.800	1	0.	-50.00000

0 SAMPLES USED   1= UNCOUNTED ZERO
0 SAMPLES IGNORED   2= COUNTED ZERO

90 / 7/4   TOTAL   37 POINTS USED

```
LEAST SQUARE FIT          Y = ( 1.0001E+00)X + (-1.4956E-01)

                          Y = ( 6.4683E-01)X** ( 1.0531E+00)

X LOG MEAN=  -.155(7.0014E-01)                    Y LOG MEAN=  -.355(4.4203E-01)
X LOG STD =   .256(1.8034E+00)                    Y LOG STD =   .312(2.0489E+00)

-----------------------------------------------------------------------------------

  DD V K      TOTAL    37 POINTS USED

LEAST SQUARE FIT          Y = (-9.9116E-01)X + (-2.3906E+00)

                          Y = ( 1.0219E-03)X** (-9.9115E-01)

X LOG MEAN= -2.613(2.4359E-03)                    Y LOG MEAN=  -.401(3.9762E-01)
X LOG STD =   .271(1.8575E+00)                    Y LOG STD =   .311(2.0475E+00)

-----------------------------------------------------------------------------------

N034 V DD0      TOTAL
AT *15:36:01*           D/D0=    4.01252     CHANNEL 10 IGNORED
AT *15:36:01*           D/D0=    4.40660     CHANNEL 11 IGNORED
AT *15:36:01*           D/D0=    4.60069     CHANNEL 12 IGNORED
AT *15:36:01*           D/D0=    5.19478     CHANNEL 13 IGNORED
AT *15:36:01*           D/D0=    5.50836     CHANNEL 14 IGNORED
AT *15:36:01*           D/D0=    5.90235     CHANNEL 15 IGNORED
AT *15:36:05*           D/D0=     .03221     CHANNEL  1 IGNORED
AT *15:36:05*           D/D0=    4.18257     CHANNEL 10 IGNORED
AT *15:36:05*           D/D0=    4.57140     CHANNEL 11 IGNORED
AT *15:36:05*           D/D0=    4.98022     CHANNEL 12 IGNORED
AT *15:36:05*           D/D0=    5.38905     CHANNEL 13 IGNORED
AT *15:36:05*           D/D0=    5.79737     CHANNEL 14 IGNORED
AT *15:36:05*           D/D0=    5.20564     CHANNEL 15 IGNORED
AT *15:36:09*           D/D0=    5.13336     CHANNEL  3 IGNORED
AT *15:36:09*           D/D0=    5.74736     CHANNEL  4 IGNORED
AT *15:36:09*           D/D0=    4.36036     CHANNEL  5 IGNORED
AT *15:36:09*           D/D0=    9.97436     CHANNEL  6 IGNORED
AT *15:36:09*           D/D0=   11.58736     CHANNEL  7 IGNORED
AT *15:36:09*           D/D0=   13.20136     CHANNEL  8 IGNORED
AT *15:36:09*           D/D0=   14.81436     CHANNEL  9 IGNORED
AT *15:36:09*           D/D0=   15.42036     CHANNEL 10 IGNORED
AT *15:36:09*           D/D0=   18.04136     CHANNEL 11 IGNORED
AT *15:36:09*           D/D0=   19.65536     CHANNEL 12 IGNORED
AT *15:36:09*           D/D0=   21.26836     CHANNEL 13 IGNORED
AT *15:36:09*           D/D0=   22.8[illegible]236     CHANNEL 14 IGNORED
AT *15:36:09*           D/D0=   24.49536     CHANNEL 15 IGNORED
AT *15:36:41*           D/D0=    4.16152     CHANNEL 11 IGNORED
AT *15:36:41*           D/D0=    4.55547     CHANNEL 12 IGNORED
AT *15:36:41*           D/D0=    4.92947     CHANNEL 13 IGNORED
AT *15:36:41*           D/D0=    5.30329     CHANNEL 14 IGNORED
AT *15:36:41*           D/D0=    5.67734     CHANNEL 15 IGNORED
AT *15:36:45*           D/D0=    4.26827     CHANNEL  9 IGNORED
```

```
AT *15:12:41*    D/D0=   [illegible]   CHANNEL  5 IGNORED
AT *15:12:41*    D/D0=   3.70775   CHANNEL  6 IGNORED
AT *15:12:41*    D/D0=  10.11635   CHANNEL  7 IGNORED
AT *15:12:41*    D/D0=  11.52436   CHANNEL  8 IGNORED
AT *15:12:41*    D/D0=  12.93757   CHANNEL  9 IGNORED
AT *15:12:41*    D/D0=  14.34217   CHANNEL 10 IGNORED
AT *15:12:41*    D/D0=  15.75071   CHANNEL 11 IGNORED
AT *15:12:41*    D/D0=  17.15939   CHANNEL 12 IGNORED
AT *15:12:41*    D/D0=  18.56795   CHANNEL 13 IGNORED
AT *15:12:41*    D/D0=  19.97650   CHANNEL 14 IGNORED
AT *15:12:41*    D/D0=  21.38520   CHANNEL 15 IGNORED
AT *15:12:45*    D/D0=   5.20035   CHANNEL  3 IGNORED
AT *15:12:45*    D/D0=   6.83435   CHANNEL  4 IGNORED
AT *15:12:45*    D/D0=   8.46855   CHANNEL  5 IGNORED
AT *15:12:45*    D/D0=  10.10235   CHANNEL  6 IGNORED
AT *15:12:45*    D/D0=  11.73726   CHANNEL  7 IGNORED
AT *15:12:45*    D/D0=  13.37156   CHANNEL  8 IGNORED
AT *15:12:45*    D/D0=  15.00536   CHANNEL  9 IGNORED
AT *15:12:45*    D/D0=  16.64016   CHANNEL 10 IGNORED
AT *15:12:45*    D/D0=  18.27446   CHANNEL 11 IGNORED
AT *15:12:45*    D/D0=  19.90876   CHANNEL 12 IGNORED
AT *15:12:45*    D/D0=  21.54306   CHANNEL 13 IGNORED
AT *15:12:45*    D/D0=  23.17737   CHANNEL 14 IGNORED
AT *15:12:45*    D/D0=  24.81167   CHANNEL 15 IGNORED
AT *15:12:49*    D/D0=    .01304   CHANNEL  1 IGNORED
AT *15:12:49*    D/D0=    .02437   CHANNEL  2 IGNORED
AT *15:12:53*    D/D0=    .02642   CHANNEL  1 IGNORED
AT *15:12:53*    D/D0=    .04678   CHANNEL  2 IGNORED
AT *15:12:53*    D/D0=   4.06559   CHANNEL 12 IGNORED
AT *15:12:53*    D/D0=   4.42109   CHANNEL 13 IGNORED
AT *15:12:53*    D/D0=   4.75648   CHANNEL 14 IGNORED
AT *15:12:57*    D/D0=   5.09137   CHANNEL 15 IGNORED
AT *15:12:57*    D/D0=    .03239   CHANNEL  1 IGNORED
AT *15:12:57*    D/D0=   4.25071   CHANNEL 10 IGNORED
AT *15:12:57*    D/D0=   4.66819   CHANNEL 11 IGNORED
AT *15:12:57*    D/D0=   5.08557   CHANNEL 12 IGNORED
AT *15:12:57*    D/D0=   5.50316   CHANNEL 13 IGNORED
AT *15:12:57*    D/D0=   5.92064   CHANNEL 14 IGNORED
AT *15:12:57*    D/D0=   5.33812   CHANNEL 15 IGNORED

     44 NON-ZERO POINTS PLOTTED

X LOG MEAN=   .856(7.1349E+00)          Y LOG MEAN=  1.051(1.1244E+01)
X LOG STD =   .79 (6.2221E+00)          Y LOG STD =  1.755(5.6948E+01)
```

BAND	SAMPLES	(ZEROS)	D/D0 FROM	TO	MID	AVE Y (Y=L*D0**4/M)	LOG(AVE Y)
1	125	(109)	.050	.100	.075	1.633E+03	3.21424
2	173	(179)	.100	.200	.150	4.043E+02	2.60677
3	144	(113)	.200	.300	.250	1.239E+02	2.09296
4	203	(160)	.300	.500	.400	4.156E+01	1.61667
5	55	(53)	.500	.700	.600	1.472E+01	1.16801
6	58	(42)	.700	.900	.800	3.055E+00	.48496
7	51	(15)	.900	1.100	1.000	4.351E+00	.63857
8	55	(73)	1.100	1.300	1.200	7.605E-01	-.11865
9	31	(62)	1.300	1.500	1.400	4.409E-01	-.35600
10	42	(70)	1.500	1.700	1.600	4.065E-01	-.39070
11	39	(35)	1.700	1.900	1.800	3.011E-02	-1.52135
12	25	(21)	1.900	2.100	2.000	1.399E-03	-2.74290
13	21	(23)	2.100	2.300	2.200	6.620E-03	-2.17012
14	19	(15)	2.300	2.500	2.400	9.948E-03	-2.00226
15	24	(23)	2.500	2.700	2.600	1.257E-03	-2.90062
16	15	(14)	2.700	2.900	2.800	4.996E-03	-2.30141

17	[illegible]	(17)	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
18	13	(13)	3.100	3.300	3.200		1.321E-03	-2.73973
19	2[illegible]	([illegible])	3.303	3.500	3.409		9.911E-04	-3.00829
20	1[illegible]	(15)	3.500	3.700	3.600		6.289E-04	-3.20144
21	1[illegible]	(13)	3.709	3.900	3.809	2	4.199E-04	-3.37666

1246 SAMPLES USED 1= UNCOUNTED ZERO
[illegible] SAMPLES IGNORED 2= COUNTED ZERO

2.1.4 Program DENPLOT

DENPLOT produces dual plots of the log of normalized number densities and normalized (or unnormalized) liquid water content versus particle diameter.

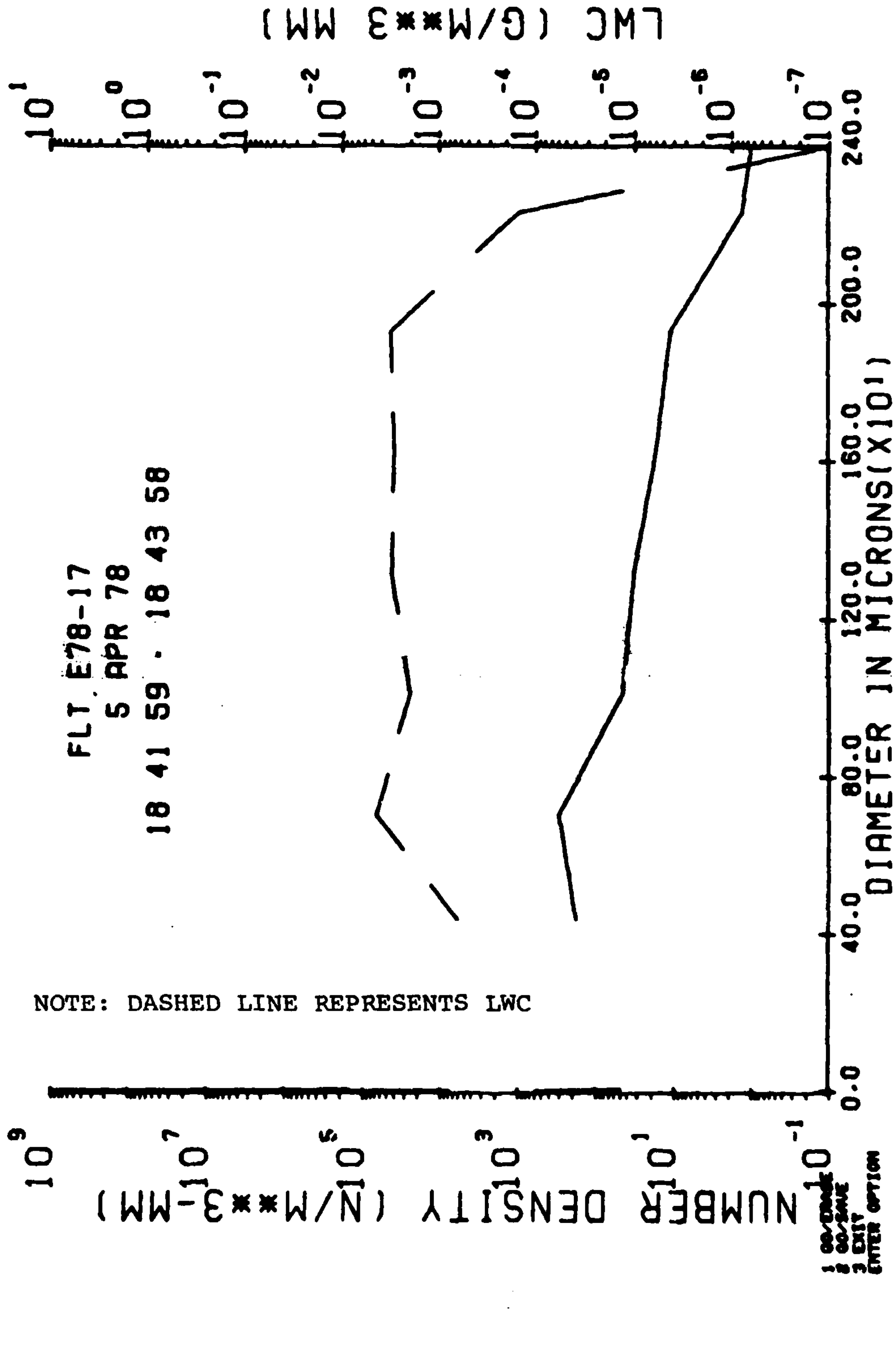
This program is run interactively from the Tektronix graphics terminal. It uses the standard output tape from KNOLL1D (TAPE2). Operating instructions and a sample plot produced by DENPLOT follow.

2.1.4.1 DENPLOT operating instructions

```
ATTACH,TAPE1,PLOTTAPE NAME,ID=NAME,MR=1
ATTACH,LGO,DENPLOTBIN,ID=GLASS,MR=1
ATTACH,CRT,CRTPLOTS,MR=1
LIBARARY,CRT
REQUEST,TAPE39,*Q
LGO

(EXECUTION BEGINS: FOLLOWING STATEMENTS REQUIRE USER RESPONSE)

NORMALIZED LWC=1,UNNORMALIZED=0 ...
STARTING PROBE (1-SC,2-CL,3-PR) ...
START TIME HH MM SS (-1-1-1 to stop) ...
SIZE LIMITS (MU) ...
LENGTH (IN SEC) OF INTERVAL TO PLOT ...

(EXECUTION CEASES WHEN -1-1-1 TYPED)

DISPOSE,TAPE39,FM
REWIND,TAPE2    CAN BE USED TO SHOW THE DISTRIBUTIONS
COPY,TAPE2      USED IN THE PLOT
LOGOUT
```

2.1.4.2 DENPLOT sample plot

DENPLOT sample plot on following page.



NOTE: DASHED LINE REPRESENTS LWC

2.1.5 Program LST1DTAPE

LST1DTAPE was written to print our various values from KNOLL1D output tape (TAPE2). The values printed are: time, LWC, Z, D_o, NT, F, TEMP, ALT, slope and intercept.

The values of LWC, Z, and D_o are for total values. NT totals are only those greater than one thousand. The slope and intercept are derived values. They are a result of a least square fit of normalized number density as a function of channel size for all non-zero Precip channels.

LST1DTAPE performs many calculations. The following narrative will provide an output description and a mathematical analysis, refer to section 2.1.5.2 for a sample output.

Start time, TEMP, ALT, LWC, Z, D_o, NT and FF are self explanatory.

<u>SLOPE AND INTERCEPT</u>

A least square fit is made between the natural log of normalized number density and center diameter (in microns) for the Precip Probe. Channel one and any one in which the number density is less than ten are excluded. For printing purposes the INTERCEPT is printed as an antilog value.

<u>S.E.E.</u>

Standard estimate of error is calculated as the difference

2.1.5 Program LST1DTAPE (cont'd)

between the original data and the calculated line:

$$S.E.E = \text{sqrt} \sum_{i=2}^{15} [(N_i - e^{(ax_i+b)\,2})] / NPTS$$

N_i is number density of channel i of the precip probe. a = SLOPE, b = INTERCEPT, x_i is the center diameter for channel i.

NPTS number of channels used, only those in which the number density is greater than 10.

AVE DEPT

The average distance between the least square fit line and the cloud probe values.

$$AVE\ DEPT = \sum_{i=1}^{15} (N_i - e^{(ax_i+b)})/NPTS$$

N_i and x_i are from the cloud probe, otherwise N_i, K_i, a, b and NPTS are similar to those values in S.E.E.

LWC % CLD

This parameter is simply the percentage of Cloud Probe LWC to the total LWC.

2.1.5 Program LST1DTAPE (cont'd)

LMAX

The largest sized particle in this sample.

PART TYPE

Particle type

The next entries are MEAN and STANDARD DEVIATIONS.

The time given is the elapsed time during which these samples were collected. The first line is the mean of all these values, the second line the standard deviations. The entries which are not printed with decimal points, were calculated as floating point numbers and then integer truncated. The table in the left corner is a KNOLL1D type table. All entries are the average of those which contributed to the table given above.

The plot is simply normalized number density as a function of channel size.

2.1.5.1 Program LST1DTAPE operating instructions

```
LOGIN,NAME,ID,TTYNUMBER,SUP
ATTACH,LGO,LST1DTAPEBIN,ID=GLASS,MR=1.
ATTACH,CRT,CRTPLOTS,MR=1
LIBRARY,CRT
REQUEST,TAPE39,*Q
ATTACH,TAPE1,PLTTAPE,ID=PLTNAME,MR=1
LGO

ENTER 30 CHARACTER MESSAGE ..... ______________________________
ENTER CLOCK = A/C, 1 = PMS ..... ______________________________

* ENTER PASS START AND STOP TIMES (HH MM SS HH MM SS).....

DISPOSE,TAPE39,FM
LOGOUT


* RECURSIVE LINE UNTIL AS MANY PLOTS ARE PRODUCED AS DESIRED.
  EXECUTION TERMINATES WHEN -1,-1,-1 USED FOR THE START TIME.
```

2.1.5.2 LST1DTAPE sample output

LST1DTAPE sample output can be found on the following page.

FLT 170 06 03 MAR 78   20 SECOND AVERAGING

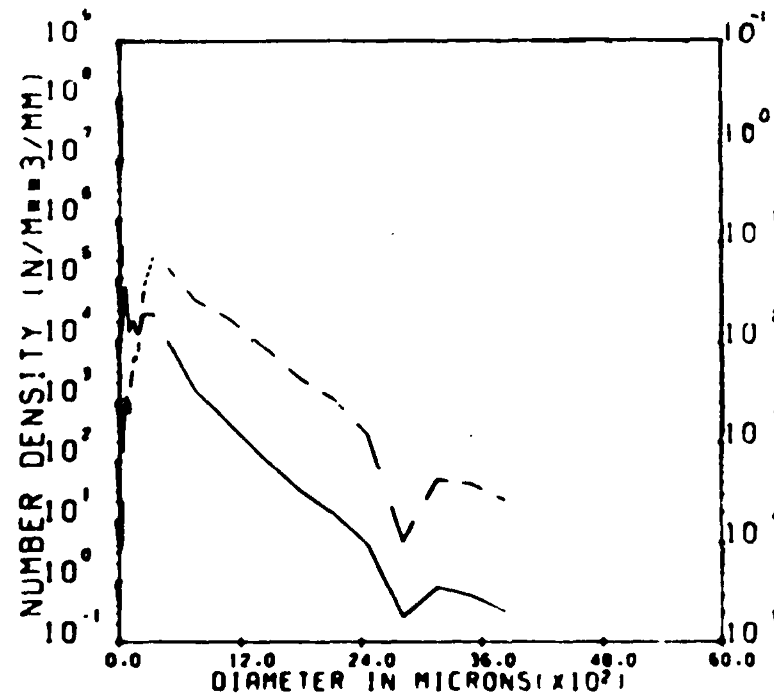
START TIME	TEMP C	ALT KM	LWC G/M**3	Z MM**6/M**3	DO MU	NT N/M**3	FF	SLOPE /MM	INTERCEPT N/M**3 MM	C.O.D.	AVE DEPT	LWC % CLD	LMAX UM	PART TYPE
21:42:20	17.0	5.6	.0212	8.1E+00	442	4120	.22	-2.1	2.04E+03	.9871	1.7083	14	3040	LS
21:42:40	17.7	5.6	.0456	5.6E+00	260	13299	.32	-3.5	2.06E+04	.9942	.9817	22	3150	LS
21:43:00	17.0	5.6	.0132	9.1E-01	220	4654	.39	-5.0	1.82E+04	.9940	.2807	20	2400	LS
21:43:20	17.9	5.6	.0463	4.3E+00	264	12765	.30	-3.7	2.66E+04	.9913	.7740	21	2460	LS
21:43:40	17.0	5.6	.0600	6.2E+00	265	20690	.37	-4.0	5.43E+04	.9761	.3915	17	2813	LS

TOT TIME   MEAN AND STANDARD DEVIATIONS

00:01:40	-17.0	5.6	.0300	5.0E+00	291	10987	.33	-3.7	2.41E+04	.9877	.8450	20	2951
00:01:40	316.5	.0	.0019	3.1E+01	90882	167990021	.12	14.2	8.73E+00	.9756	.9990	4508980919	

PARTICLE SIZE DISTRIBUTION (N/M**3 MM)

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE
2	4.90E+07	27	1.24E+04	[illegible]	[illegible].07E+04
4	1.01E+08	50	7.43E+04	744	[illegible]47E+03
6	1.25E+08	73	3.00E+04	1089	3.8[illegible]E+02
7	1.16E+08	96	1.35E+04	1434	1.00E+02
9	7.08E+07	119	1.96E+04	1779	3.27E+01
11	6.09E+07	142	2.00E+04	2124	1.33E+01
13	3.30E+07	165	1.33E+04	2469	4.12E+00
15	4.33E+07	188	1.24E+04	2814	2.64E-01
16	2.04E+07	211	1.69E+04	3159	8.31E-01
18	1.60E+07	234	2.67E+04	3504	5.83E-01
20	1.56E+07	257	2.87E+04	3849	3.16E-01
22	1.17E+07	280	2.50E+04	4194	0.
23	1.10E+07	303	2.66E+04	4539	0.
25	1.00E+07	326	2.66E+04	4884	0.
27	7.63E+06	349	2.27E+04	5229	0.
LWC	1.25E-03		7.70E-03		3.11E-02



2.1.6 Program VCOTIME

VCOTIME is a general plotting program available for use on any standard plotting device. Up to two parameters can be plotted in a time frame. In addition scatter plots of one parameter versus another may be done. When this option is used a linear least square fit line is drawn through the data.

VCOTIME uses tape 2 from KNOLL1D as its data base and obtains pass times and plot information interactively from the user. It can plot all the VCO and meteorological parameters as well as the four probe LWC's, Z's and MK's. An additional feature of the program is the ability to generate log axis, optionally, instead of real.

2.1.6.1 Program VCOTIME operating instructions

COMMAND MODE

```
LOGIN,NAME,ID#,TTY#,SUP
ATTACH,LGO,VCOTIMEBIN,ID=GLASS,MR=1
ATTACH,TAPE1,PLTTAPENO,ID=NAME,MR=1   (KNOLL1D OUTPUT TAPE)
ATTACH,CRT,CRTPLOTS.*
LIBRARY,CRT.*
ATTACH,TEK,TEKLIB.**
LIBRARY,TEK.**
ATTACH,PEN,ONLINEPEN***
LIBRARY,PEN.***
REQUEST,TAPE39,*Q.* OR **
REQUEST,PLOT,*Q.*
ETL,200.
LGO.

ANSWER QUESTIONS IN USER MODE BELOW.
WHEN DONE TYPE.

* OR **DISPOSE,TAPE39,FM.
***DISPOSE,PLOT,PL.
LOGOUT
```

```
*     USED WHEN MICROFICHE DESIRED
**    USED WHEN OPERATING FROM TEKTRONIX GRAPHICS TERMINAL
***   USED WHEN PEN PLOTS DESIRED
```

2.1.6.1 Program VCOTIME operating instructions (cont'd)

USER MODE

User responds to questions by typing in response and pressing return button. Initially one question is asked about the plotting device then a series of questions are asked for each individual plot. Plotting is terminated when negative start and stop times are typed.

INITIAL QUESTION ASKED

INPUT PLOT DEVIECE (1=TEK OR CRT, 2=PEN)...

PLOT QUESTIONS ASKED

INPUT START AND STOP TIMES IN FORM HH MM SS HH MM SS....
USE NEG START OR STOP TIME TO END PROGRAM...

DO YOU WANT A SCATTER PLOT (TYPE YES OR NO)...

*INPUT # OF TIME PLOTS ON FRAME (1 OR 2)...

** INPUT PARAMETER # (1-37 NEG FOR LOG PLOT)...

** LIMITS OF PARAMETER ARE MIN TO MAX

** TYPE YES TO CHANGE LIMITS (NO OTHERWISE)...

** AND *** INPUT NEW MIN AND MAX (FREE FORMAT)...

* ONLY USED WHEN SCATTER PLOT NOT DESIRED

** THESE LINES REPEATED WHEN SCATTER PLOT DESIRED OR TIME PLOTS ON FRAME EQUALS 2

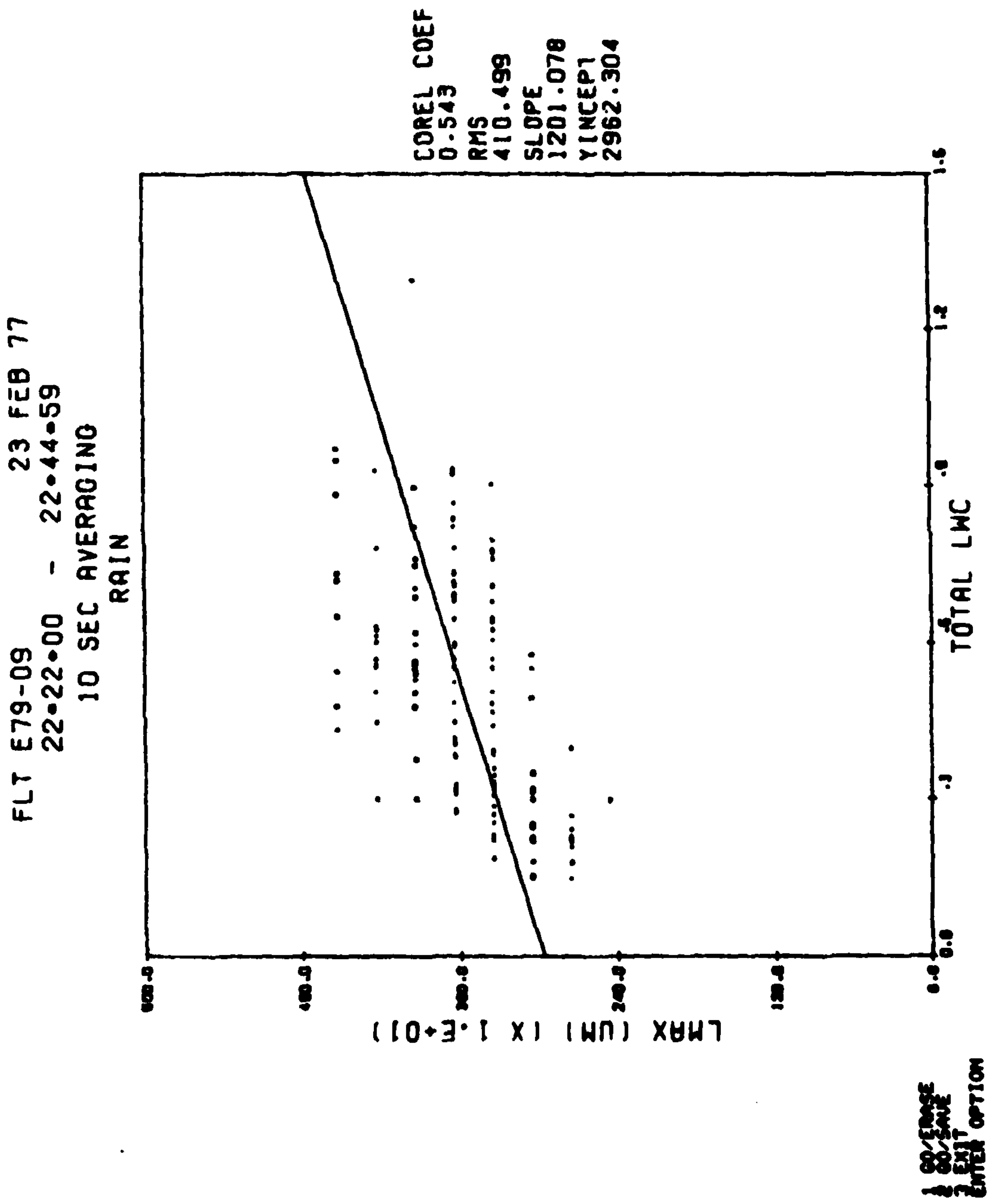
*** OPTIONAL

2.1.6.1 Program VCOTIME operating instructions (cont'd)

PARAMETER ID LIST

#	PARAMETERS	DEFAULT MIN	DEFAULT MAX
1	PRESSURE (Mb)	1025.	275.
2	EWER (COUNTS)	0.	10000.
3	HEIGHT (M)	0.	10000.
4	TRUE TEMP (C)	-35.	15.
5	DEWP/FROST (C)	-35.	15.
6	JW-LWC (G/M**3)	0.	1.5
7	ICING RATE (COUNTS)	0.	10000.
8	TWCI-LWC	0.	1.
9	IAS (MIS)	0.	200.
10	MAG HEAD (DEG)	0.	360.
11	CAL AIRSPEED (M/S)	0.	150.
12	TRUE AIRSPEED (M/S)	0.	150.
13	TWCI-1	0.	10000.
14	SCAT LWC (G/M**3)	0.	1.
15	CLOUD LWC (G/M**3)	0.	1.5
16	PRECIP LWC (G/M**3)	0.	1.5
17	TOTAL LWC (G/M**3)	0.	1.5
18	SCAT Z	0.	1000.
19	CLOUD Z	0.	10000.
20	PRECIP Z	0.	100000.
21	TOTAL Z	0.	100000.
22	SCAT D0 (MU)	0.	32.
23	CLOUD D0	0.	300.
24	PRECIP D0	0.	6000.
25	TOTAL D0	0.	6000.
26	SCAT MK	0.	100.
27	CLOUD MK	0.	100.
28	PRECIP MK	0.	100.
29	TOTAL MK	0.	100.
30	FORM FACTOR	0.	1.
31	NT (N/M**3)	0.	100000.
32	POTT TEMP (K)	250.	350.
33	DEWPOINT (C)	-35.	15.
34	SAT VAPOR (Mb)	0.	20.
35	VAPOR (Mb)	0.	20.
36	REL HUMID (%)	0.	100.
37	LMAX (MU)	0.	5000.

2.1.6.2 VCOTIME sample plot



2.1.7 Program JWEXTR and JWPLOT

JWEXTR and JWPLOT are optional programs in the PMS-1D job stream. The purpose of these programs is to calculate the altitude, slope and intercepts used to make corrections to the calibrated JW-LWC values.

JWEXTR is the first program run. It strips off the time, calibrated JW-LWC and height values from the Kennedy tape. Since each seconds data will comprise only 3 CDC words an entire flight will comprise less than 1000 PRU's. This can easily be handled as on-line data by the stream.

JWPLOT is then run on this data at the Tektronix graphic terminal and a scatter plot of height versus JW-LWC is produced. On the plot can be viewed layers of points representing a pass during the flight. By lining up the cross hairs of the graphics terminal at the apex of the layers the program will automatically calculate the parameters necessary for the JW adjustment.

Section 2.1.7.3 graphically illustrates the before and after plots produced by JWPLOT. See section 2.1.3.6 for a description of the adjustment made. Operating instructions for these programs are found in the following sections.

2.1.7.1 Program JWEXTR operating instructions

```
DPSI,CM40000,T200,TP1,STMPK.        ID NAME
ATTACH,LGO,JWEXTRBIN,ID=GLASS,MR=1.
VSN,TAPE1=PMSXXX.   (KENNEDY 1D TAPE)
REQUEST,TAPE1,MT,HI,NORING,S.
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
LDSET,PRESET=ZERO.
LGO.
EXIT(U)
CATALOG,TAPE2,PFNAME,ID=XXXX.
7/8/9

DATA CARDS
CARD 1
COL 5          ICLOCK          1... USE A/C CLOCK
                               2... USE PMS CLOCK
COL 10         IFAS            1... USE TRUE AIRSPEED
                               2... USE CALC. AIRSPEED
COL 11-15      NREC            # OF RECORDS TO SKIP
COL 20-27                      PMS ON TIME (HH:MM:SS)

6/7/8/9
```

2.1.7.? Program JWPLOT operating instructions

NOTE: JWPLOT IS DESIGNED TO RUN INTERACTIVELY ON A TEKTRONIX 4014 TERMINAL

THE INITIALIZATION PROCEDURE IS AS FOLLOWS:

```
LOGIN,NAME,PASSWORD,TEL#,SUP.
ATTACK,LGO,JWPLOTBIN,ID=GLASS,MR=1.
ATTACH,TAPE1,JWEXTRDATA,ID=XXXX.
ATTACH,TAPE3,JWADJDATA,ID=XXXX.*
REQUEST,TAPE2,*Q.**
ATTACH,TEK,TEKSIM,CY=?***
LIBRARY,TEK.
ETL,100.    (EXTEND NORMAL CP TIME LIMIT)
LGO.
- USE THE FOLLOWING PLOTTING PROCEDURES
DISPOSE,TAPE2,PR,IAC.**
LOGOUT
```

* OPTIONAL PREDEFINED JWADJ COEFFICIENTS

** FILE UNIT ON WHICH JWADJ PROFILE AND DATA SUMMARY IS PRODUCED

*** USE CY=1 FOR TEKTRONIX #1, CY=2 for #2

2.1.7.2 Program JWPLOT operating instructions (cont'd)

PLOTTING PROCEDURE FOLLOWS:

USER RESPONDS TO THE FOLLOWING PROMPTS

```
1     "ENTER IN THE START & STOP TIMES (HH MM SS HH MM SS)
2A    "DEFAULT VALUES FOR HT(KM) ARE 0,10
      DO YOU WISH TO CHANGE THE LIMITS? (YES,NO)"
2B    "ENTER THE NEW LIMITS FOR HT(KM) (MIN,MAX)"
3A    "DEFAULT LIMITS FOR JW-LWC ARE -.5,1.5
      DO YOU WISH TO CHANGE THE LIMITS? (YES,NO)"
      IF RESPONSE IS YES
3B    "ENTER THE NEW LIMITS FOR JW-LWC (G/M**3) (MIN,MAX)"
4     "ENTER IN FLT ID (FLT EXX-XX)"
5     "ENTER IN FLT DATE (DD MMM YY)"
```

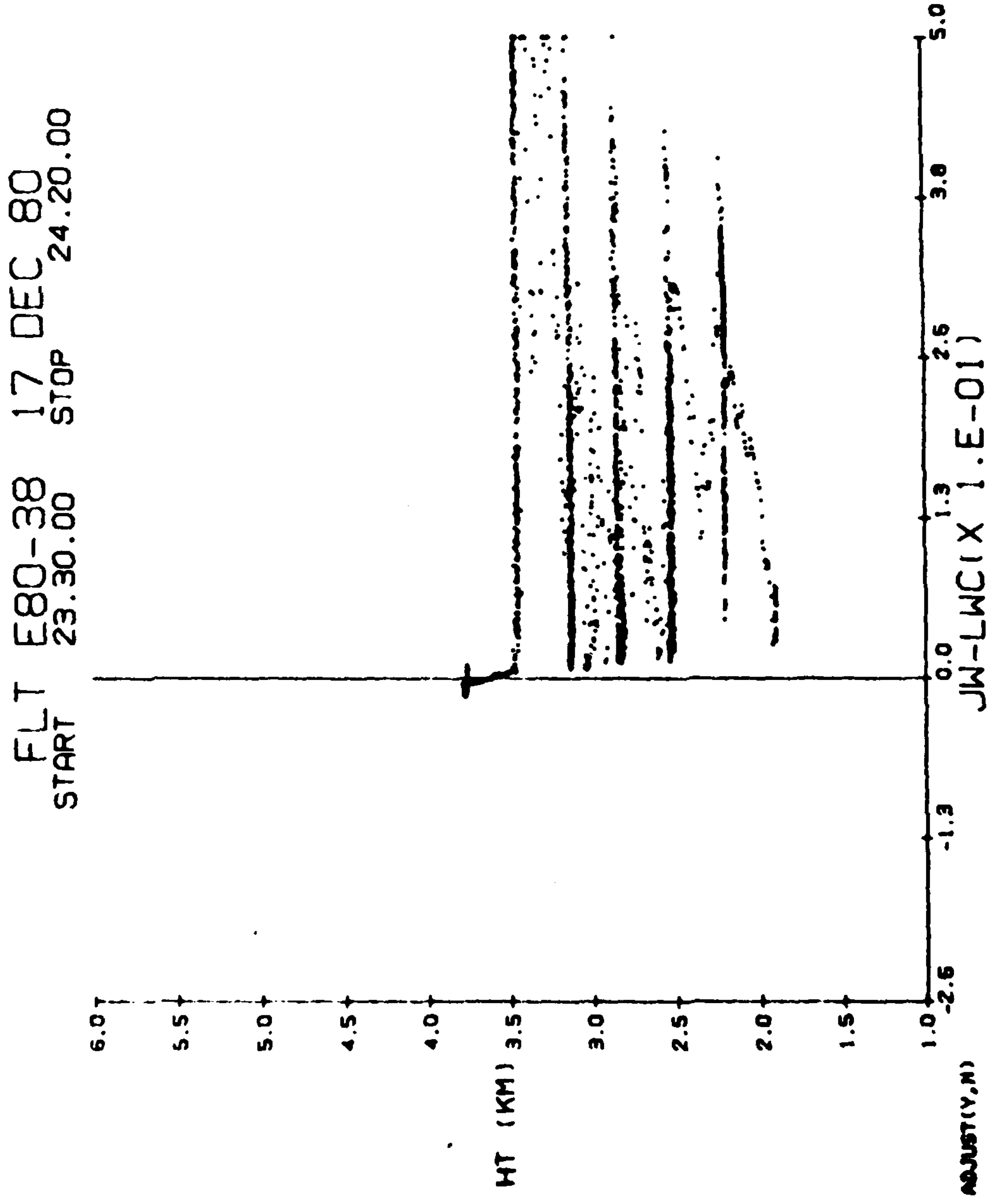
After the flight date has been entered the raw JW-LWC vs. HEIGHT plot will be produced. When completed a prompt, "adjust (Y,N)", will appear in the lower left corner. A response of N will use the existing JWADJ profile supplied as TAPE3 to adjust and plot the corrected values.

A response of Y will initiate the adjusting procedure using graphic input. The user will respond to the light cross hairs by positioning the intersection at minimum LWC values of the layered data (see section 2.1.7.3). Care must be taken to input values in descending order by height. The positional values are entered by responding with an integer (1-9) without a carriage return. The process is halted by entering a 0 for the last integer.

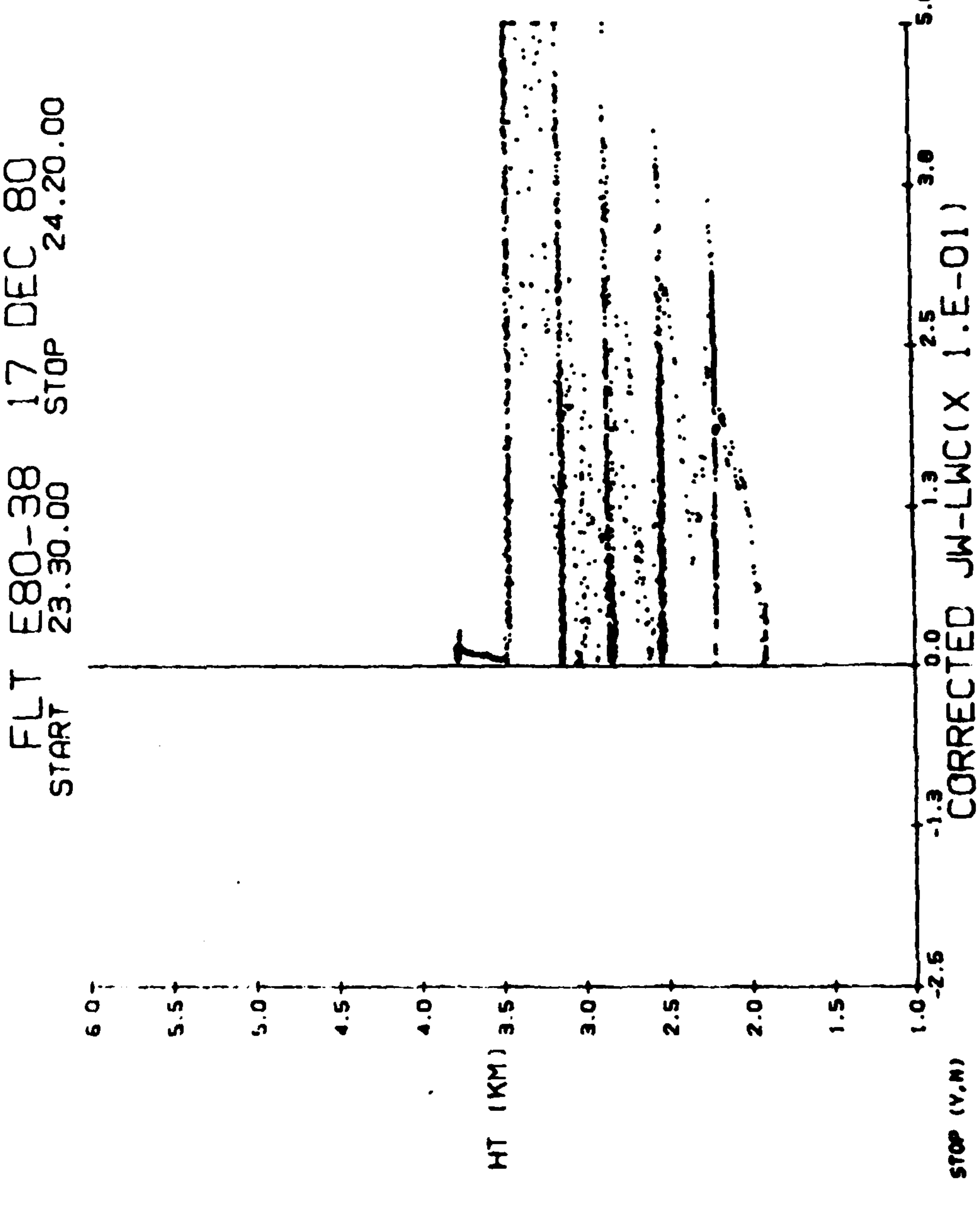
2.1.7.2 Program JWPLOT operating instructions (cont'd)

When the adjusted JW-LWC plot is completed respond N to the "stop (Y,N)" prompt. Don't forget to dispose TAPE2 to obtain a copy of the JWADJ profile.

2.1.7.3 JWPLOT sample plots (BEFORE & AFTER)



2.1.7.3 JWPLOT sample plots (BEFORE & AFTER) (cont'd)



2.1.7.4 JWPLOT sample output

FLT L6(-3517 DEC A

START...23 30 00
STOP....24 20 00

JW ADJUSTMENT PROFILE

```
HT(01)= 7.76, XA(01)=-.01731, SLA01)= .06330
HT( 2)= 3.47, XA( 2)= .0015 , SLA02)= .01355
HT(03)= 3.13, XA(03)= .01601, SLA03)= .01090
HT(04)= 2.62, XA(04)= .00945, SLA04)= .00357
HT(05)= 2.52, XA( 5)= .01051, SLA05)= .11061
HT(06)= 2.21, XA(06)= .04523, SLA06)=-.07133
HT(07)= 1.91, XA(07)= .02417, SLA07)=0.00000
```

TIME	ALT (KM)	JW-LWC	ADJ JW-LWC		TIME	ALT (KM)	JW-LWC	ADJ JW-LWC
23 30 00	1.9124	.0668	.0426	!	23 30 01	1.9124	.0746	.0465
23 30 02	1.9115	.0666	.0426	!	23 30 03	1.9115	.0607	.0364
23 30 04	1.9124	.063[illegible]	.0388	!	23 30 05	1.9115	.0637	.0394
23 30 06	1.9115	.0613	.0370	!	23 30 07	1.9104	.0574	.0332
23 30 08	1.9115	.0566	.0323	!	23 30 09	1.9104	.0573	.0331
23 30 10	1.9124	.0474	.0232	!	23 30 11	1.9104	.0497	.0255
23 30 12	1.9104	.0489	.0247	!	23 30 13	1.9094	.0435	.0194
23 30 14	1.9084	.0495	.0255	!	23 30 15	1.9074	.0435	.0196
23 30 16	1.9064	.0456	.0211	!	23 30 17	1.9054	.0555	.0317
23 30 18	1.9044	.0699	.0461	!	23 30 19	1.9054	.0576	.0338
23 30 20	1.9034	.0327	.0090	!	23 30 21	1.9044	.0281	.0043
23 30 22	1.9044	.0362	.0125	!	23 30 23	1.9064	.0370	.0131
23 30 24	1.9074	.0332	.0094	!	23 30 25	1.9115	.0319	.0067
23 30 26	1.9145	.0311	.0066	!	23 30 27	1.9195	.0273	.0025
23 30 28	1.9235	.0250	-.0001	!	23 30 29	1.9296	.0437	.0182
23 30 30	1.9346	.0624	.0365	!	23 30 31	1.9396	.0730	.0468
23 30 32	1.9457	.0851	.0584	!	23 30 33	1.9518	.0881	.0610
23 30 34	1.9578	.0830	.0614	!	23 30 35	1.9619	.0844	.0566
23 30 36	1.9689	.0907	.0624	!	23 30 37	1.9740	.0999	.0712
23 30 38	1.9730	.1049	.0759	!	23 30 39	1.9841	.1250	.0955
23 30 40	1.9902	.1377	.1073	!	23 30 41	1.9963	.1476	.1173
23 30 42	2.0013	.1474	.1168	!	23 30 43	2.0074	.1552	.1211
23 30 44	2.0125	.1533	.1213	!	23 30 45	2.0196	.1591	.1271
23 30 46	2.0257	.1711	.1387	!	23 30 47	2.0398	.1747	.1420
23 30 48	2.0379	.1784	.1451	!	23 30 49	2.0440	.1792	.1455
23 30 50	2.0502	.1857	.1516	!	23 30 51	2.0563	.1737	.1391
23 30 52	2.0624	.1729	.1379	!	23 30 53	2.0675	.1744	.1391
23 30 54	2.0767	.1788	.1428	!	23 30 55	2.0698	.1836	.1473
23 30 56	2.0869	.1896	.1528	!	23 30 57	2.0931	.2073	.1698
23 30 58	2.0992	.2116	.1742	!	23 30 59	2.1064	.2029	.1646
23 31 00	2.1115	.2037	.1652	!	23 31 01	2.1177	.2038	.1648
23 31 02	2.1259	.1947	.1553	!	23 31 03	2.1300	.1974	.1576
23 31 04	2.1351	.2007	.1605	!	23 31 05	2.1433	.2108	.1702
23 31 06	2.1455	.2287	.1873	!	23 31 07	2.1526	.2332	.1917
23 31 08	2.1568	.2365	.1947	!	23 31 09	2.1640	.2323	.1901
23 31 10	2.1691	.2415	.1989	!	23 31 11	2.1743	.2362	.1932
23 31 12	2.1815	.2279	.1845	!	23 31 13	2.1867	.2349	.1870
23 31 14	2.1908	.2257	.1815	!	23 31 15	2.1960	.1996	.1551
23 31 16	2.2011	.1655	.1446	!	23 31 17	2.2053	.1655	.1203
23 31 18	2.2054	.1615	.1157	!	23 31 19	2.2115	.1519	.1073
[illegible]	[illegible]	[illegible]	[illegible]	!	[illegible]	[illegible]	[illegible]	[illegible]

2.1.8 Program CHCOUNT

Program CHCOUNT compares the Forward Scattering Cloud Droplet (FSSP) and Axial Scattering (ASSP) Probes. This is done by comparison of channel counts generated by the FSSP and ASSP hardware. The probes size particles by counting the number of occluded diodes that result from a shadow caused by the interdiction of the particle with a focused laser beam. Use of the standard calibration range resolves these occlusions into 15 size ranges (channels).

Comparison of the scattering probes by channel counts is valid only when the calibration ranges for both probes are the same (during the testing flights this occurred approximately 25% of the time). It was determined that only channel counts of intersecting size ranges (between probes) should be used.

The comparison of total channel counts for coincident size ranges can indicate that the probes are looking at the same spectra. A more detailed analysis must be done by using some normalized routine to minimize functional differences between the probes. Several methods have been tried and it was decided to normalize each channel count probe cross sectional area and diode width, and the aircraft true airspeed. This gives the channel counts a volume representation and, when summed for coincident size ranges, a good comparative parameter.

No assumption can be made about the validity of the spectral representation for either the ASSP or FSSP probes;

2.1.8 Program CHCOUNT (cont'd)

outside data sources, in conjunction, would need to be used for that purpose. Statistical parameters, for comparison purposes, must necessarily be derived from the total volume for each probe.

Two parameters are calculated from the total normalized counts for coincident size ranges. They are as follows:

1 FSSP dispersion about the mean of total particles (FDIVM)

$$FDIVM = (M-F)/M$$

2 FSSP dispersion about total ASSP particles (FDIVA)

$$FDIVA = (A-F)/2$$

where:

A = total normalized counts for ASSP probe
F = total normalized counts for FSSP probe
M = (A+F)/2

FDIVM can best be thought of as a number representing how much the FSSP or ASSP contributes to the mean. A returned value of 1 indicates that the ASSP contributes everything while -1 indicates the FSSP does. FDIVA are values in the range $(-\alpha,1)$ which indicates a relationship between the two probes. Equality returns a value of 0, ASSP domination returns a value tending toward 1 while FSSP domination tends

2.1.8 Program CHCOUNT (cont'd)

toward $-\alpha$. For example:

FDIVA = 1/2 means that A = 2xF

while

FDIVA = -2 means that F = 2xA

Program CHCOUNT provides a graphic representation of the above data. In addition it was decided to add a switch that would exclude channel 1 of ASSP, FSSP or both from all calculations. This is necessary since these channels are suspect, in some cases. Normal program operation is without this switch set.

A *microfiche* output of the probe spectra is included. Two plots are produced per pass segment (see sec. 2.1.8.2). The first is the normalized channel counts versus channel center diameter. The second is a cumulative sum of these normalized counts versus center diameter (for coincident channels only). This is a fair representation of how the spectral distribution contributes to the total value. Each plot contains data for both probes, on the same scaling, hence a direct visual comparison can be made.

Operating instructions for program CHCOUNT may be found on the following pages.

2.1.8.1 Program CHCOUNT operating instructions

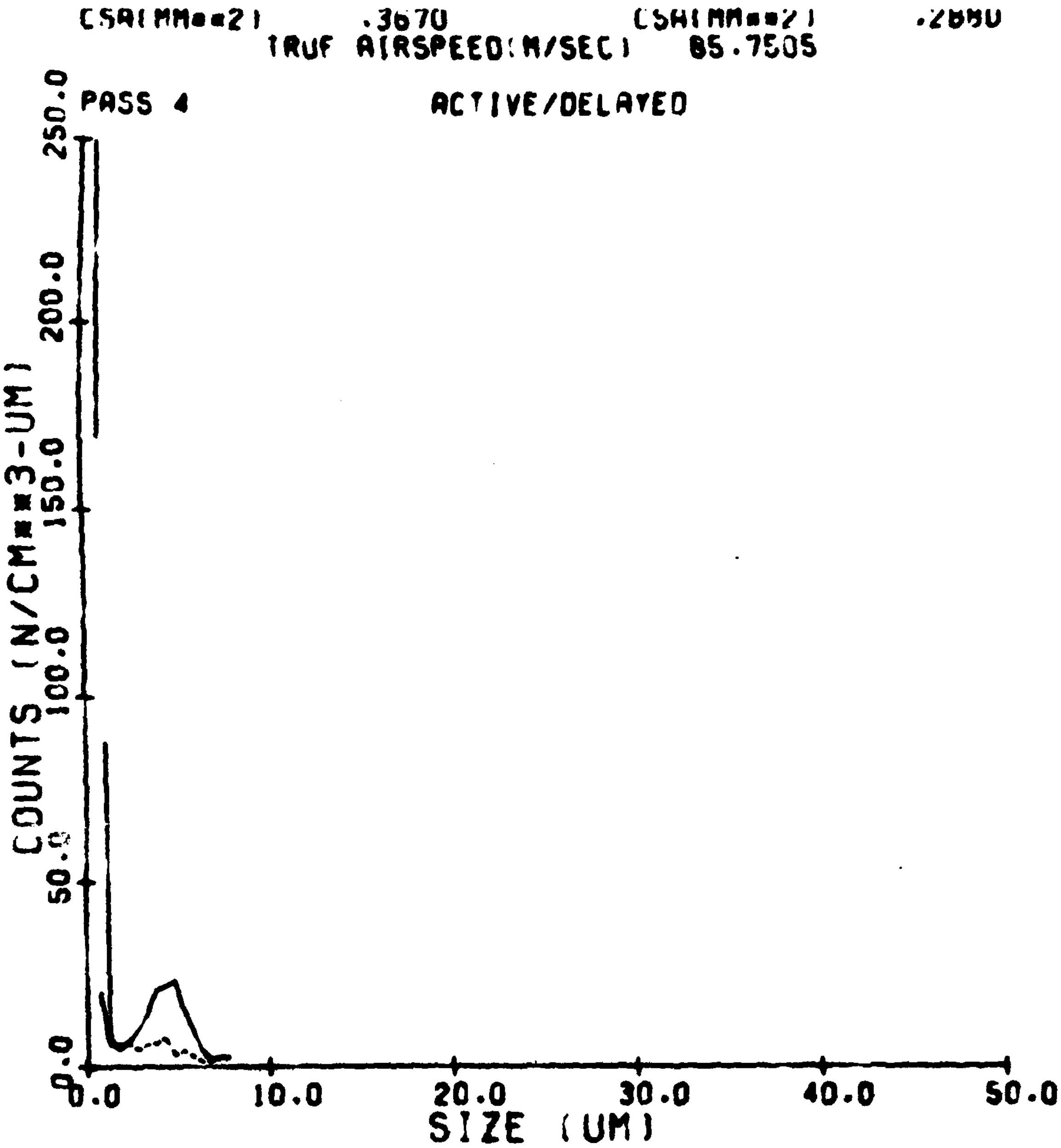
```
            CONTROL CARDS
NAME,CM55000,T400,TP1.          ID NAME
VSN,TAPE=PMSID.
REQUEST,TAPE1,S,HI,NORING,MT.
ATTACH,CRT,CRTPLOTS.
LIBRARY,CRT.
REQUEST,TAPE39,*Q.
DISPOSE,TAPE39,*FM.
ATTACH,LGO,CHCOUNTBIN,ID=GLASS,MR=1.
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
LDSET,PRESET=ZERO.
LGO.
7/8/9
            DATA CARDS
HEADER CARD
COL  1-9  IDATE - FLIGHT DATE (DD MON YY)
COL 11-16 ID - FLIGHT ID
COL 17-20 NSKIP - NUMBER OF EOF'S TO SKIP BEFORE PROCESSING
          DATA
COL 21-25 IPROBE - CANNISTER CONTAINS FSSP (1=CLOUD, 2=PRECIP)
COL 26-30 ICLOCK - WHICH CLOCK TO USE (1=A/C, 2=PMS)
COL 43-50 IH:IM:IS (PMS CLOCK-ZERO SECONDS)
PASS CARD
COL  2-9  IH:IM:IS - PASS START TIME
COL 12-19 IH:IM:IS - PASS STOP TIME
COL 21-30 INT - AVERAGING INTERVAL
COL 31-40 ASCA - ASSP CROSS SECTIONAL AREA (MM**2) IN F10.4 FORMAT
COL 41-50 FCSA - FSSP CROSS SECTIONAL AREA (MM**2) IN F10.4 FORMAT
COL 51-60 ASIZE - ASSP DIODE WIDTH (UM) IN F10.4 FORMAT
```

2.1.8.1 Program CHCOUNT operating instructions (cont'd)

COL 61-70 FSIZE - FSSP DIODE WIDTH (UM) IN F10.4 FORMAT
COL 71-75 CH1ASSP - CHANNEL ONE ASSP NOT USED WHEN = 1
COL 76-80 CH1FSSP - CHANNEL ONE FSSP NOT USED WHEN = 1
PASS LITERAL CARD
COL 1-50 LITERAL - CENTERED IN THE FIRST 50 COLUMNS

FOR EVERY PASS CARD THERE MUST BE ONE LITERAL CARD FOLLOWING IT. USE AS MANY PAIRS OF PASS AND LITERAL CARDS AS NEEDED IN TIME INCREASING ORDER.

2.1.8.2 CHCOUNT sample plot



2.1.8.3 CHCOUNT sample output

CHCOUNT sample output on the following page.

ASSP/FSSP SCATTER PROBE COMPARISON

E79-44 8 SEP 79 296 SECONDS DATA

14:59:53 TO *15:04:48*

ASSP	SC. CAN.	FSSP	PR. CAN.
DW(UM)	2.1000	DW(UM)	.5000
CSA(MM**2)	.3670	CSA(MM**2)	.2980

PASS 4 ACTIVE/DELAYED

FSSP DISP. ABOUT MEAN OF TOTAL PARTICLES -.650 FSSP DISP. ABOUT TOTAL ASSP PARTICLES -3.707

ASSP SIZE RANGE (UM)	COUNTS	CUM SUM (COUNTS)	N/(MM**2*UM)	CUM SUM (N/(MM**2*UM))	I	*FSSP* SIZE RANGE (UM)	COUNTS	CUM SUM (COUNTS)	N/(MM**2*UM)	CUM SUM (N/(MM**2*UM))
(2.0- 4.0)	228	228(228)	310.63	3.11E+2(3.11E+2)	I	(.5- 1.0)	78669	******(78669)	364208.33	*******(3.64E+5)
(4.0- 6.0)	187	415(415)	254.77	5.65E+2(5.65E+2)	I	(1.0- 1.5)	808	******(79477)	5611.11	*******(3.70E+5)
(6.0- 8.0)	15	431(431)	21.80	5.87E+2(5.87E+2)	I	(1.5- 2.0)	137	******(79614)	951.39	*******(3.71E+5)
(8.0-10.0)	2	******(433)	2.72	*******(5.90E+2)	I	(2.0- 2.5)	155	55(79769)	1076.39	1.08E+3(3.72
(10.0-12.0)	2	******(435)	2.72	*******(5.93E+2)	I	(2.5- 3.0)	81	236(79850)	562.50	1.64E+3(3.72
(12.0-14.0)	1	******(436)	1.36	*******(5.94E+2)	I	(3.0- 3.5)	80	316(79930)	555.56	2.19E+3(3.73
(14.0-16.0)	0	******(436)	0.00	*******(5.94E+2)	I	(3.5- 4.0)	63	379(79993)	437.50	2.63E+3(3.73
(16.0-18.0)	0	******(436)	0.00	*******(5.94E+2)	I	(4.0- 4.5)	17	396(80010)	118.06	2.75E+3(3.74
(18.0-20.0)	0	******(436)	0.00	*******(5.94E+2)	I	(4.5- 5.0)	1	397(80011)	6.94	2.76E+3(3.74
(20.0-22.0)	1	******(436)	0.00	*******(5.94E+2)	I	(5.0- 5.5)	1	398(80012)	6.94	2.76E+3(3.74E+5)
(22.0-24.0)	0	******(436)	0.00	*******(5.94E+2)	I	(5.5- 6.0)	0	398(80012)	0.00	2.76E+3(3.74E+5)
(24.0-26.0)	0	******(436)	0.00	*******(5.94E+2)	I	(6.0- 6.5)	0	398(80012)	0.00	2.76E+3(3.74E+5)
(26.0-28.0)	0	******(436)	0.00	*******(5.94E+2)	I	(6.5- 7.0)	0	398(80012)	0.00	2.76E+3(3.74E+5)
(28.0-30.0)	0	******(436)	0.00	*******(5.94E+2)	I	(7.0- 7.5)	0	398(80012)	0.00	2.76E+3(3.74E+5)
(30.0-32.0)	0	******(436)	0.00	*******(5.94E+2)	I	(7.5- 8.0)	0	398(80012)	0.00	2.76E+3(3.74E+5)

ASSP/FSSP SCATTER PROBE COMPARISON

E79-44 8 SEP 79 296 SECONDS DATA

15:04:49 TO *15:09:44*

ASSP	SC. CAN.	FSSP	PR. CAN.
DW(UM)	2.1000	DW(UM)	.5000
CSA(MM**2)	.3670	CSA(MM**2)	.2880

PASS 4 ACTIVE/DELAYED

FSSP DISP. ABOUT MEAN OF TOTAL PARTICLES .024 FSSP DISP. ABOUT TOTAL ASSP PARTICLES .048

ASSP SIZE RANGE (UM)	COUNTS	CUM SUM (COUNTS)	N/(MM**2*UM)	CUM SUM (N/(MM**2*UM))	I	*FSSP* SIZE RANGE (UM)	COUNTS	CUM SUM (COUNTS)	N/(MM**2*UM)	CUM SUM (N/(MM**2*UM))
(2.0- 4.0)	45	46(45)	62.67	6.27E+1(6.27E+1)	I	(.5- 1.0)	84584	******(84584)	391592.59	*******(3.92E+5)

2.1.9 PMS-1D data tape archiving

A method of archiving the Kennedy tapes has been developed to copy six 800 BPI 7-track tapes onto one 3200 BPI 9-track tape. In this manner older tapes, not generally used, may be recycled to free much needed space in the tape cabinets.

The Cyber Control Language (CCL) and system routines of the CDC system are utilized in this procedure to successfully copy the six PMS-1D tapes onto one 9-track output tape. Since only two tape drives are required at any one time, priority levels for this job are not high and throughput time will be one day generally.

CCL is used to process any errors that occur during the job and will ensure all six tapes are successfully copied. If problems develop they will appear in the job day file. The job could then be resubmitted to copy only from the problem area onwards. This would save some duplication of efforts.

Once a successful tape is produced, program TEST1DCOPY can verify the copies. After a successful test, the six old PMS tapes can be recycled. The above archiving and testing should require at most 2-4 days throughput time to produce one output tape.

2.1.9 PMS-1D data tape archiving (cont'd)

CONTROL CARDS

```
  DPSI,T1000,NT1,TP1.                         ID#       ID NAME
  MAP,OFF.
  FTN,B=SKIP2.
  FTN,B=HEAD2.
  FTN,B=WEOF2.
  COPYCR,,TPCOPY.
* SET,R1=#.
  COMMENT. SET R1 TO THE NUMBER OF TAPES TO
  COMMENT. COPY - WHEN R1 IS 6 HEADER FOR TAPE 2
  COMMENT. IS WRITTEN - WHEN R1 IS LESS THAN SIX
  COMMENT. 6-R1 PREVIOUSLY COPIED FILES ARE SKIPPED
  DISPLAY,R1.
  VSN,TAPE2=OUTPUT TAPE NUMBER/NT.
  IFE,R1.EQ.6,LABINF.
  REQUEST,TAPE2,NT,RING,N.
  REWIND,TAPE2.
  HEAD2.
  WEOF2.
  ELSE,LABINF.
  REQUEST,TAPE2,NT,RING,E.
  REWIND,TAPE2
  SET,R2=7-R1.
  COMMENT. R2 IS THE NUMBER OF EOF'S TO SKIP
  COMMENT. BEFORE PROCESSING
  DISPLAY,R2.
  WHILE,R2.NE.0,SKTP2.
  SKIP2.
  SET,R2=R2-1.
  ENDW,SKTP2.
  ENDIF,LABINF.
```

2.1.9 PMS-1D data tape archiving (cont'd)

```
   SET,R3=0.
   WHILE,R1.NE.0,COPYT2.
   SET,R3=R3+1.
** IFE,R3.EQ.1,ONE.
** TPCOPY,PMS#1.  (KENNEDY TAPE)
** ENDIF,ONE.
** IFE,R3.EQ.2,TWO.
** TPCOPY,PMS#2.  (KENNEDY TAPE)
** ENDIF,TWO.
** IFE,R3.EQ.3,THREE.
** TPCOPY,PMS#3.  (KENNEDY TAPE)
** ENDIF,THREE.
** IFE,R3.EQ.4,FOUR.
** TPCOPY,PMS#4.  (KENNEDY TAPE)
** ENDIF,FOUR.
** IFE,R3.EQ.5,FIVE.
** TPCOPY,PMS#5.  (KENNEDY TAPE)
** ENDIF,FIVE.
** IFE,R3.EQ.6,SIX.
** TPCOPY,PMS#6.  (KENNEDY TAPE)
** ENDIF,SIX.
   COMMENT. FINISHED A TAPE COPY
   DISPLAY,R3.
   SET,R1=R1-1.
   ENDW,COPYT2.
   EXIT(U)
   WEOF2.
```

2.1.9 PMS-1D data tape archiving (cont'd)

DATA CARDS

```
7/8/9
      PROGRAM SKIP2(INPUT,OUTPUT,TAPE2)
      INTEGER DUM(8)
      BUFFER IN(2,1)(DUM(1),DUM(8))
      IF(UNIT(2))100,100,100
100   BUFFER IN(2,0)(DUM(1),DUM(2)
      IF(UNIT(2))100,200,100
200   STOP $ END
7/8/9
      PROGRAM HEAD2(INPUT,OUTPUT,TAPE2)
      INTEGER HEAD(8)
      READ 1,HEAD
    1 FORMAT(8A10)
      WRITE 2,HEAD
    2 FORMAT(5X,8A10)
      BUFFER OUT (2,1)(HEAD(1),HEAD(8)
      IF(UNIT(2))100,100,100
100   STOP $ END
7/8/9
      PROGRAM WEOF2(INPUT,OUTPUT,TAPE2)
      ENDFILE 2
      STOP $ END
7/8/9
```

2.1.9 PMS-1D data tape archiving (cont'd)

DATA CARDS (CONT'D)

```
     .PROC,TPCOPY,VSNUM.
     COMMENT. NOW IN PROCEDURE TPCOPY
     UNLOAD,TAPE1.
     VSN,TAPE1=VSNUM.
     HEAD2.
     REQUEST,TAPE1,S,HI,MT,NORING.
     REWIND,TAPE1.
     FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
     COPYBF,TAPE1,TAPE2.
     REVERT.
     EXIT(s)
     WEOF2.
     REVERT.
     7/8/9
 *** TAPE2 HEADER CARD
**** HEADER INFORMATION CARDS - MAXIMUM OF SIX
     6/7/8/9
```

2.1.9 PMS-1D data tape archiving (cont'd)

NOTES:

*	SET R1 TO THE NUMBER OF TAPES TO COPY. IT IS ASSUMED THAT SIX ARE TO BE COPIED INITIALLY: THUS ONLY THE HEADER FOR TAPE2 IS WRITTEN WHEN R1 IS 6. ADDITIONALLY, IF WE DESIRE TO RERUN PART OF THE JOB (6-R1) DATA FILES WILL BE SKIPPED BEFORE COPYING TO TAPE2.
**	PMS NUMBER REFERS TO THE 1D DATA ID. AS MANY SETS AS REQUESTED BY R1 MUST BE INCLUDED HERE.
***	THIS CARD ONLY INCLUDED WHEN R1 IS 6. WHEN USING THIS CARD PLACE A 7/8/9 CARD AFTER IT.
****	AS MANY CARDS AS R1 MUST BE INCLUDED HERE. IN THE ORDER THEY APPEAR IN ** ABOVE. EACH INFORMATION CARD MUST HAVE A 7/8/9 CARD IMMEDIATELY FOLLOWING IT.

2.1.10 Program TEST1DCOPY

TEST1DCOPY was recently written to verify the archiving of PMS-1D data tapes (section 2.1.9). This program inputs the original and archived tapes, and produces octal dumps of variable numbers (user input) of records. These octal dumps are visually compared and verified. Operating instructions appear below; no sample output will be presented.

```
COMMAND DECK
DPSI,NT1,T25.                    ID#       ID NAME
MAP,OFF
ATTACH,LGO,TEST1DCOPYBIN,ID=GLASS,MR=1.
VSN,TAPE1=PMSXXX.
REQUEST,TAPE1,S,HI,MT,NORING.
VSN,TAPE2=ARCHIEVENUMBER/NT.
REQUEST,TAPE2,NT,NORING,E.
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105).
LGO.
7/8/9

     1 DATA CARD
CC 1-5    NEOF(I5 FORMAT) - NUMBER OF EOF's ON TAPE2 TO SKIP
CC 6-10   NREC(I5 FORMAT) - NUMBER OF RECORDS TO DUMP

6/7/8/9
```

2.1.11 Program COPPMS

COPPMS is a general purpose copying program (for 1D data). It has been written to handle all necessary data manipulation. Once the data has been formatted, proper use of the appropriate control cards will give the desired tape format.

PMS 1D data is produced by the Knollenberg 1D device on board the C-130E aircraft used by AFGL. The on board Kennedy recorder stores data on a seven track, 800 BPI tape. Each record consists of a 4 second buffer containing 1024 characters. Each character is in 4 bit BCD with 2 leading bits (totalling 6 bits per/character).

Program COPPMS buffers in binary the 1024 character record. A 256 word array of values (64 consecutive words per second) is created by taking each consecutive 4 characters, masking to zero the two leading bits (of each character) and doing the following internal conversion:

(4 character word)	001000	000100	000100	000001
	8	4	7	1

becomes

(value) $8 * 1000 + 4 * 100 + 7 \times 10 + 1 \times 1 = 8471$

The 256 word array of values must be suitably formatted for output. This is done by encoding the 256 word array into one of 103 words by using I4.4 format. At this point buffering out coding (of the packed characters) and the proper use

2.1.11 Program COPPMS (cont'd)

of the REQUEST control card (consult appropriate system manual) will result in the tape being formatted properly. In the above cases use of a nine track drive defaults to ASCII code, while use of seven track drive defaults to BCD.

Two other parts were considered in the writing of COPPMS. First, the whole tape is not always copied thus the use of passes was incorporated into the program. Second, data from more than one flight or non-consecutive data of the same flight can be written to a tape. In that case use of the elapsed second counter (when problems arise with the A/C clock) has no meaning. Therefore we must make sure the aircraft clock registers appropriate times. If the aircraft clock was not working properly we must use the elapsed second counter of the source data tape to generate correct times. The calculated time is written over the A/C clock before the data is encoded and buffered out.

2.1.11 Program COPPMS (cont'd)

Operating Instructions

Control Cards

```
*DECKID,CM40000,TP2,T200.                  ID        NAME
ATTACH,LGO,COPPMSBIN,ID=GLASS,MR=1.
VSN,TAPE1=PMS###.
REQUEST,TAPE1,S,HI,NORING,MT.
VSN,TAPE2=TAPENO.
**REQUEST,TAPE2,S,RING,...
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
FILE(TAPE2,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
LGO.

7/8/9
```

Option Card

```
COLUMNS         1-5            ***NEOF
                5-10              ICLOCK(1=A/C,2=PMS)
               13-20              PMS STRAT TIME(HH:MM:SS)
          -PASS CARDS-            (ONLY USED IF CLOCK=2)
IH IM IS IH IM IS                 (START & STOP TIMES IN
                                  TIME INCREASING ORDER)
```

*   IF NINE TRACK TAPE DESIRED CHANGE ,TP2, TO ,TP1,NT1.

**   USE PROPER PARAMETERS TO OBTAIN DESIRED FORMATING.

*** NUMBER OF END OF FILES TO SKIP BEFORE PROCESSING THE DATA. DATA IS WRITTEN OVER THE LAST END OF FILE MARK.

2.2 Radar analysis and correlation

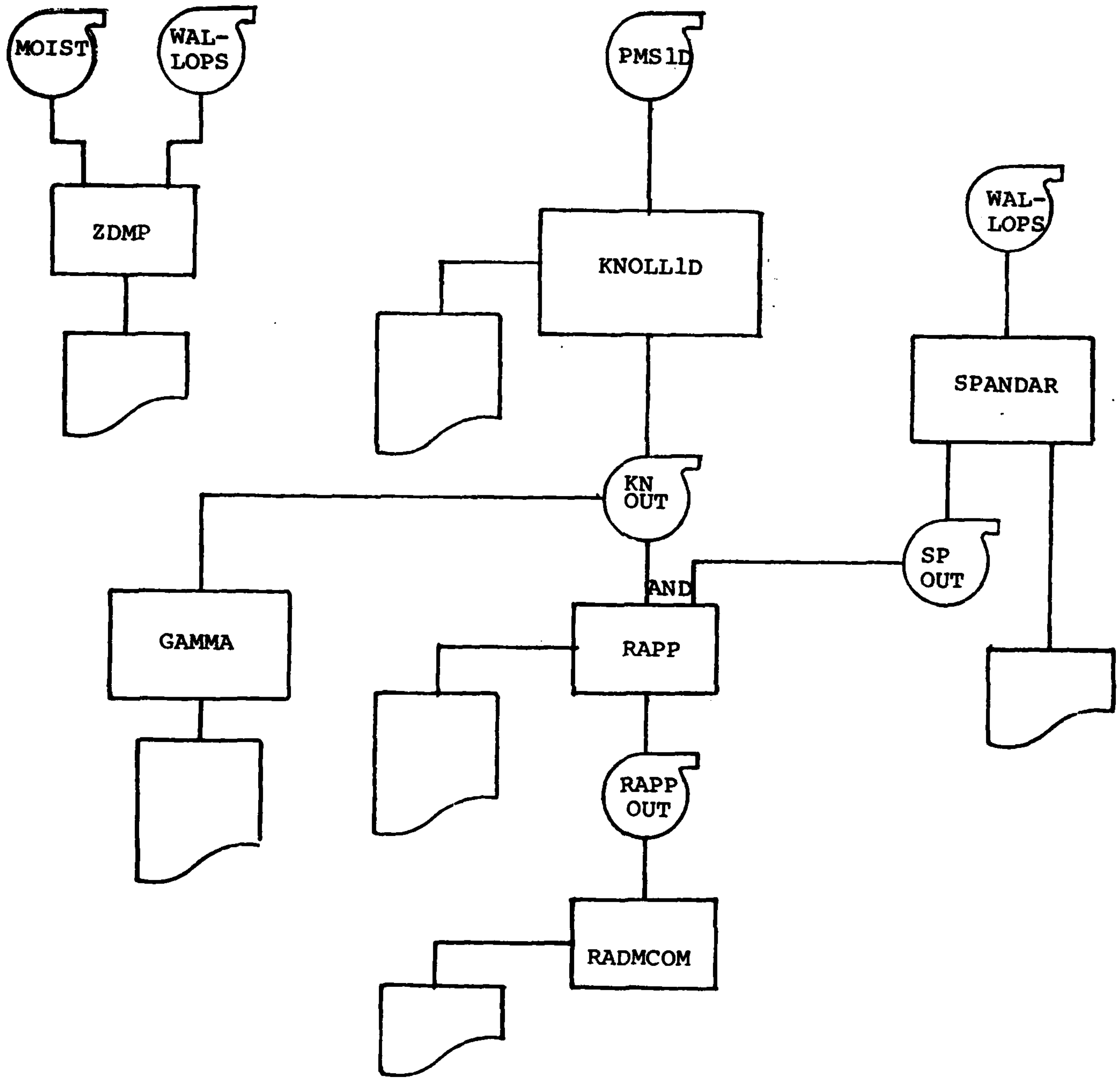
The radar processing programs play an important role in the synoptic analysis of aircraft recorded data. A ground based radar can determine the mass present in a given amount of space. This mass can be transformed easily into liquid water content. The ability to obtain radar data in the same time and space of the aircraft observations enables an objective analysis of the 1D and 2D PMS devices.

Figure 2.5 shows the processing flow used in radar analysis. The data arrived at LYC in one of two ways; a 'moist' data tape from the Kwajalein missle range, or a preprocessed tape from Wallops Island. The Wallops Island tapes were first processed by program SPANDAR to obtain a compatible tape for analysis. Both tapes can be verified by program ZDMP which produces a data dump.

Program RAPP does most of the analysis work. RAPP uses a KNOLL1D output tape along with a radar tape to produce comparisons. Program GAMMA uses a KNOLL1D output tape and radar data tape to analyze water content and reflectivity. Program RADMCOM is a continuation of RAPP analysis
LWC to reflectivity relationships.

A more detailed description of the individual programs can be found in the following sections.

Figure 2.15: Radar Analysis And Correlation Program Flow



2.2.1 Program RAPP

RAPP is the primary program used for correlating radar and aircraft data. The program accepts aircraft one second data produced by KNOLL1D or HIAC1D and radar data in moist format (radar data from the Kwajalein missile range that has been preprocessed by another contractor) or Wallops Island data. Wallops Island data must be preprocessed by program SPANDAR to put it in a suitable format for program RAPP.

One second data is accepted and all averaging takes place within the program. Radar data is optionally accepted with some modifications as follows:

(a) If Wallops data - add 6.5 dBZ for everything except rain.

(b) If Kwajalein data:
- (b1) If ice below 4.6 km add 6.5 dBZ
- (b2) If rain above 4.6 km subtract 6.5 dBZ

Program RAPP correlates data collected from the PMS 1D and 2D devices aboard the C130-E or the LEARJET with data acquired from a ground based radar. The correlated data is then plotted in a variety of ways:

1) aircraft "MK' vs. radar "Z"
2) aircraft "Z" vs. aircraft "M"
3) aircraft "Z" and aircraft "M" vs. time
4) aircraft "Z" and radar "Z" vs. time
5) aircraft "MK" and radar "Z" vs. time.
6) aircraft "Z" vs. radar "Z"
7) aircraft "M" vs. radar "Z"

2.2.1 Program RAPP (cont'd)

where

M is liquid water content GM/M**3
Z is radar reflectivity
MK is defined as 1000*M/√Z

The output listing consists of tabulated data points, correlation percentages for shifts of aircraft-radar matchings of ±3 seconds, and least square regression coefficients for plots 1, 2, 6, 7 listed previously. The graphical output uses 105mm film generated by a CALCOMP CRT plotter.

The following output description refers to the sample outputs produced by program RAPP (labelled 'A' to 'H').

PAGE A

Listing of input options. Top right hand corner lists the date, time of execution, and the version of RAPP used. Underneath are two lines of comments input on data cards, two cards of 42 characters each.

The next information printed is a listing of aircraft parameters; aircraft, date of flight, probe selected, clock selected and the aircraft running mean interval.

Following these are radar parameters, if needed, the collecting radar, radar offset distance, radar correction, minimum detectable signal, radar tape format, and the radar

2.2.1 Program RAPP (cont'd)

running mean averaging.

Since there could be independent radar/aircraft running means, the program lists the final time shift caused by the running mean.

The program has a set of default limits which are used to set axis ranges and these are listed. Remember for scatter plots, a full size plot is made and then the data is "blown up" to fill the frame for a second plot, see the appendix.

At the bottom of the page is a listing of the pass parameters. Pass number 15 input. The radar time range is dependent on the aircraft time requested. It is a function of aircraft time, less the time it takes the aircraft to traverse the offset distance and finally the time shift caused by the interaction between independent running means. Of course the aircraft and radar times are also affected by the radar data available.

The aircraft velocity is calculated by taking the range, azimuth for the first and last times within the requested time period and then deriving the speed by the law of cosines.

The time offset, given in integer seconds, is the result of dividing the offset distance by airspeed. The aircraft time was already described. The LWC rejection is the input values per pass or default. Same for Radar. If any LWC

2.2.1 Program RAPP (cont'd)

falls outside the range, the matching aircraft-radar points are ignored. The same for the radar.

The average height is given by the radar for the radar time period. The radar adjustment is a pass by pass adjustment to each radar DBZ. There is also a total adjustment as described earlier.

PAGE B & C

This is a printout of original aircraft data and the resulting running mean values. Notice at 08:32:33 the derived value exceeds the maximum LWC and therefore was ignored.

There are two sets of output for the aircraft data one set lists LWC, MK and Z, the other (PAGE C) lists LWC, NT and F.

At the end of each set of aircraft data, the average of all accepted points is printed.

PAGE D

This table lists the original radar values, and of course their running mean. The page heading lists all the input options. The radar correction (top right) is the sum of the global correction and this pass' correction. The columns are self evident excepting the last two. The ICE/WATER is the dielectic constant for ICE/WATER $\pm$6.5 DB. See the specification letter for its

2.2.1 Program RAPP (cont'd)

constraints. The last column unlabelled, is the point by point difference between the pass offset time and this particular second, note that almost all values are less than 0.5. The last line of output lists the average of accepted points, the RMS and the time shift.

The RMS is the error of this full time shift (15.22 - full value of 15 given on PAGE A). This RMS = 16.67 seconds. Normally this should cause alarm, but what is not printed is a page where the radar reversed itself and gave values of 13, -14, 16 causing this large number.

PAGE E

This page lists the cross correlation percentages for time shifts of ± 3 seconds. The highest correlation determines how many seconds the data is shifted.

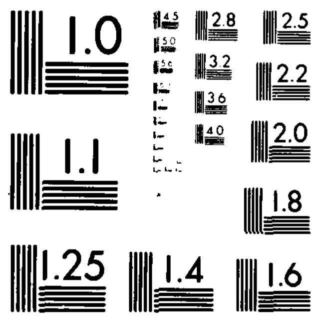
For each value, the six aircraft and one radar, the maximum and minimum are found along with their first four moments. These calculations are done twice, once for normal data and then for the common logs of the data.

PAGE F & G

List the least square fits of each parameter with their RMS. These values are all calculated and reported in log values unless otherwise indicated.

AD-A109 929 DIGITAL PROGRAMMING SERVICES INC WALTHAM MASS F/G 4/2
DEVELOPMENT AND APPLICATIONS OF TECHNIQUES TO PROCESS HYDROMETE--ETC(U)
JUL 81 L E BELKSY, F B KAPLAN, J P LALLY F19628-78-C-0131
UNCLASSIFIED AFGL-TR-81-0261 NL

3 OF 7
AD
A109929



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

2.2.1 Program RAPP (cont'd)

PAGE H

Lists each time plot as it is produced.

An additional rejection has been implemented within RAPP.

2.2.1 Program RAPP (cont'd)

This rejection system ignores DBZ values within a given range if the associated PP-OP parameter is less than a certain value. (see below for table.)

To maintain program flexibility these rejection values must be input whenever this option is selected. Thus if the option is not selected, the program requires the standard input deck and will execute exactly as before. Only when the option flag is set, see section 2.2.1.2 for operating instructions, are there any processing differences.

Functionally, the table values are input and printed. When subroutine READ is called to verify the pass times, all values which will be rejected are printed with the appropriate identification. When subroutine RADFIL is called each radar value is checked and if it is rejected it is reset to below the nominal default value. Thus guaranteeing that it will not be used in the data analysis.

If the DBZ value is within the limits below, the accompaning PP-OP value must be greater than the one listed for that range.

LOWER	UPPER	PP-OP VALUE
***	0.0	20.0
0.0	10.0	19.0
10.0	20.0	18.0
20.0	30.0	17.0
30.0	40.0	16.0
40.0	50.0	15.0
50.0	60.0	14.0
60.0	****	11.0

LOWER < DBZ < UPPER REQUIRES PP-OP > TABLE VALUE

Figure 2.16: PP-OP value limits

2.2.1.1 RAPP sample output

RAPP sample output labelled 'A' through 'H' are found on the following eight pages.

PROGRAM: RAPP
VERSION: 4.00.03
RUN DATE: 08/09/79
PROCESSED: 12.46.19.

TESTING THE EFFECTS OF USING VARIOUS RUNNING MEANS FOR BOTH THE AIRCRAFT AND RADAR

AIRCRAFT: LEAR
DATE: 04 JUL 78
PROBE: CLOUD + PRECIP
CLOCK: STANDARD
AVERAGING INTERVAL FOR AIRCRAFT RUNNING MEAN: 3 SECOND(S)

RADAR: ALCOR
RADAR OFFSET DISTANCE: 3000.00 METERS
RADAR CORRECTION: 0.00 DB
MINIMUM DETECTABLE RADAR SIGNAL AT 1 KILOMETER: -400.00 DB
RADAR TYPE CODE: 1
AVERAGING INTERVAL FOR RADAR RUNNING MEAN: 5 SECOND(S)

THE RUNNING MEAN SHIFTS THE AIRCRAFT DATA 1.00 SECONDS
THE RUNNING MEAN SHIFTS THE RADAR DATA 2.00 SECONDS
THE AIRCRAFT DATA IS THUS SHIFTED BY -1.00 SECONDS

DEFAULT VALUES FOR PLOT LIMITS

PARAMETER	MINIMUM	MAXIMUM
A/C MK	1.0000E-03	1.0000E+03
A/C LWC	1.0000E-06	1.0000E+02
A/C Z	1.0000E-04	1.0000E+04
A/C NT	1.0000E+00	1.0000E+08
A/C F	1.0000E-05	1.0000E+01
RADAR Z	1.0000E-04	1.0000E+04

PASS	RADAR START	RADAR STOP	A/C VELOCITY	OFFSET	AIRCRAFT START	AIRCRAFT STOP	L W C REJECTION MINIMUM	L W C REJECTION MAXIMUM	RADAR REJECTION MINIMUM	RADAR REJECTION MAXIMUM	AVERAGE HEIGHT	RADAR ADJUST
1	08:29:00 -	08:32:42	197.05	15	08:29:16 -	08:32:58	1.000E-05	1.000E-01	1.000E-04	1.000E+04	14485.12	0.00

A

AIRCRAFT TIME	AVERAGED TIME	DATA ACCEPTED	ORIGINAL LWC	INITIAL REJECTION	DERIVED LWC	ORIGINAL MK	DERIVED MK	ORIGINAL Z	DERIVED Z
03:31:49	03:31:49.00		1.561[illegible]-02		1.7697E-02	1.2626E+02	1.1828E+02	1.7313E-02	2.2623E-02
03:31:50	03:31:50.00		2.126[illegible]-02		1.8092E-02	1.2470E+02	1.2878E+02	2.9253E-02	2.0387E-02
03:31:51	03:31:51.00		1.640[illegible]-02		1.8382E-02	1.3577E+02	1.2615E+02	1.4596E-02	2.1889E-02
03:31:52	03:31:52.00		1.748[illegible]-02		1.6534E-02	1.1836E+02	1.3540E+02	2.1819E-02	1.5697E-02
03:31:53	03:31:53.00		1.5714E-02		1.5351E-02	1.5208E+02	1.4816E+02	1.0677E-02	1.3100E-02
03:31:54	03:31:54.00		1.4356E-02		1.5492E-02	1.7404E+02	1.4454E+02	6.8042E-03	1.6668E-02
03:31:55	03:31:55.00		1.9407E-02		1.5350E-02	1.0751E+02	1.4563E+02	3.2584E-02	1.5755E-02
03:31:56	03:31:56.00		1.3787E-02		1.6550E-02	1.5533E+02	1.4469E+02	7.8776E-03	1.6565E-02
03:31:57	03:31:57.00		1.6456E-02		1.5346E-02	1.7124E+02	1.5572E+02	9.2353E-03	1.5924E-02
03:31:58	03:31:58.00		1.7595E-02		1.6338E-02	1.4060E+02	1.4411E+02	1.5660E-02	1.3440E-02
03:31:59	03:31:59.00		1.4964E-02		1.6512E-02	1.2049E+02	1.3327E+02	1.5424E-02	1.5353E-02
03:32:00	03:32: 0.00		1.6976E-02		1.6755E-02	1.3872E+02	1.2927E+02	1.4976E-02	1.6902E-02
03:32:01	03:32: 1.00		1.6325E-02		1.6751E-02	1.2560E+02	1.3656E+02	2.0305E-02	1.6579E-02
03:32:02	03:32: 2.00		1.4953E-02		1.7967E-02	1.2437E+02	1.2067E+02	1.4456E-02	2.3507E-02
03:32:03	03:32: 3.00		2.1522E-02		1.9159E-02	1.0906E+02	1.1630E+02	3.5759E-02	2.7277E-02
03:32:04	03:32: 4.00		2.1501E-02		1.9377E-02	1.2149E+02	1.1619E+02	3.1615E-02	2.9755E-02
03:32:05	03:32: 5.00		1.7468E-02		1.9510E-02	1.1903E+02	1.1522E+02	2.1754E-02	2.9417E-02
03:32:06	03:32: 6.00		1.9822E-02		1.8725E-02	1.0514E+02	1.1031E+02	3.4681E-02	2.9374E-02
03:32:07	03:32: 7.00		1.8344E-02		1.9431E-02	1.0676E+02	1.1340E+02	3.1487E-02	2.9965E-02
03:32:08	03:32: 8.00		1.9526E-02		2.0092E-02	1.2770E+02	1.1823E+02	2.7526E-02	2.9229E-02
03:32:09	03:32: 9.00		2.1615E-02		2.1176E-02	1.2363E+02	1.2208E+02	3.2674E-02	3.0155E-02
03:32:10	03:32:10.00		2.1398E-02		2.1611E-02	1.1930E+02	1.1789E+02	3.4266E-02	3.3620E-02
03:32:11	03:32:11.00		2.1132E-02		2.0362E-02	1.1474E+02	1.1949E+02	3.3921E-02	3.0031E-02
03:32:12	03:32:12.00		1.9557E-02		2.0492E-02	1.2544E+02	1.2023E+02	2.4307E-02	2.9326E-02
03:32:13	03:32:13.00		2.0763E-02		1.9102E-02	1.2159E+02	1.2361E+02	2.3743E-02	2.4166E-02
03:32:14	03:32:14.00		1.6361E-02		1.9764E-02	1.2487E+02	1.2455E+02	1.8447E-02	2.5563E-02
03:32:15	03:32:15.00		2.1364E-02		1.7437E-02	1.2574E+02	1.3539E+02	2.8412E-02	1.8314E-02
03:32:16	03:32:16.00		1.3895E-02		1.7713E-02	1.5456E+02	1.2937E+02	8.0829E-03	2.1504E-02
03:32:17	03:32:17.00		1.7579E-02		1.6571E-02	1.0581E+02	1.3199E+02	2.8016E-02	1.7376E-02
03:32:18	03:32:18.00		1.7820E-02		1.9375E-02	1.3460E+02	1.1668E+02	1.7528E-02	2.9394E-02
03:32:19	03:32:19.00		2.2426E-02		2.1383E-02	1.0561E+02	1.2397E+02	4.2632E-02	3.1552E-02
03:32:20	03:32:20.00		2.3923E-02		2.2150E-02	1.2969E+02	1.1353E+02	3.4497E-02	3.5322E-02
03:32:21	03:32:21.00		2.6120E-02		2.2346E-02	1.0344E+02	1.1677E+02	3.7833E-02	3.8811E-02
03:32:22	03:32:22.00		2.4846E-02		2.3274E-02	1.1817E+02	1.1423E+02	4.4099E-02	4.1393E-02
03:32:23	03:32:23.00		2.4886E-02		2.4534E-02	1.2198E+02	1.1909E+02	4.2241E-02	4.2449E-02
03:32:24	03:32:24.00		2.3999E-02		2.2370E-02	1.1802E+02	1.1736E+02	4.1003E-02	3.6328E-02
03:32:25	03:32:25.00		2.0125E-02		2.2355E-02	1.1297E+02	1.1464E+02	3.1735E-02	3.8124E-02
03:32:26	03:32:26.00		2.3040E-02		2.3366E-02	1.1292E+02	1.1275E+02	4.1626E-02	4.6252E-02
03:32:27	03:32:27.00		2.8734E-02		2.6350E-02	1.1237E+02	1.1151E+02	5.5794E-02	5.6457E-02
03:32:28	03:32:28.00		2.7275E-02		2.5340E-02	1.0923E+02	1.1335E+02	6.2347E-02	5.3884E-02
03:32:29	03:32:29.00		2.1810E-02		2.2776E-02	1.1544E+02	1.1595E+02	7.3911E-02	4.0631E-02
03:32:30	03:32:30.00		1.9241E-02		2.1302E-02	1.2318E+02	1.1875E+02	2.5635E-02	3.2431E-02
03:32:31	03:32:31.00		2.2554E-02		2.2338E-02	1.1763E+02	1.1676E+02	3.7747E-02	3.7475E-02
03:32:32	03:32:32.00		2.4318E-02		2.4479E-02	1.1252E+02	1.1594E+02	4.9642E-02	4.4786E-02
03:32:33	03:32:33.00	*IGNORED*	2.5665E-02		3.0102E-01	1.1767E+02	8.2928E+01	4.7574E-02	6.9333E+02
03:32:34	03:32:34.00	*IGNORED*	5.4949E-01		3.0110E-01	1.8627E+01	7.9518E+01	2.0799E+03	6.9333E+02
03:32:35	03:32:35.00	*IGNORED*	2.5141E-02		2.9366E-01	1.0226E+02	8.0220E+01	5.7444E-02	6.9333E+02
03:32:36	03:32:36.00		2.4344E-02		2.7716E-02	1.1977E+02	1.1013E+02	4.1712E-02	4.7242E-02
03:32:37	03:32:37.00		2.1662E-02		2.2524E-02	1.0835E+02	1.1647E+02	3.9971E-02	3.7632E-02
03:32:38	03:32:38.00		2.1560E-02		2.1364E-02	1.2170E+02	1.1133E+02	3.1613E-02	3.9586E-02
03:32:39	03:32:39.00		2.2664E-02		2.4583E-02	1.0435E+02	1.1247E+02	4.7174E-02	4.9994E-02

B

AIRCRAFT TIME	AVERAGED TIME	DATA ACCEPTED	ORIGINAL LWC	INITIAL REJECTION	DERIVED LWC	ORIGINAL NT	DERIVED NT	ORIGINAL F	DERIVED F
08:32:40	08:32:40.00		2.9819E-02		2.5681E-02	2.4960E+05	2.1346E+05	4.2721E-01	4.4302E-01
08:32:41	08:32:41.00		2.4559E-02		2.5260E-02	1.9130E+05	2.2129E+05	4.5563E-01	4.3968E-01
08:32:42	08:32:42.00		2.1403E-02		2.3351E-02	2.2297E+05	2.1605E+05	4.3622E-01	4.4284E-01
08:32:43	08:32:43.00		2.5590E-02		2.2535E-02	2.3389E+05	2.2026E+05	4.3668E-01	4.4496E-01
08:32:44	08:32:44.00		2.0523E-02		2.2489E-02	2.0390E+05	2.1494E+05	4.6199E-01	4.4678E-01
08:32:45	08:32:45.00		2.1553E-02		2.0431E-02	2.0721E+05	2.0480E+05	4.4168E-01	4.5093E-01
08:32:46	08:32:46.00		1.9416E-02		1.9502E-02	2.0349E+05	1.9733E+05	4.4911E-01	4.5958E-01
08:32:47	08:32:47.00		1.6035E-02		1.8594E-02	1.8150E+05	1.9111E+05	4.8794E-01	4.7287E-01
08:32:48	08:32:48.00		1.8034E-02		2.7764E-02	1.8335E+05	1.8760E+05	4.8156E-01	4.6507E-01
08:32:49	08:32:49.00		2.5527E-02		2.1394E-02	1.9355E+05	1.9821E+05	4.8570E-01	4.7919E-01
08:32:50	08:32:50.00		2.1725E-02		2.2490E-02	2.1272E+05	2.0493E+05	4.7031E-01	4.6361E-01
08:32:51	08:32:51.00		2.0117E-02		1.9295E-02	2.0952E+05	2.1787E+05	4.3481E-01	4.6456E-01
08:32:52	08:32:52.00		1.6044E-02		1.9157E-02	2.3239E+05	2.1699E+05	4.8862E-01	4.5076E-01
08:32:53	08:32:53.00		2.1809E-02		1.7388E-02	2.1506E+05	2.0279E+05	4.2868E-01	4.7926E-01
08:32:54	08:32:54.00		1.5911E-02		1.6538E-02	1.5993E+05	1.8623E+05	5.2053E-01	4.6641E-01
08:32:55	08:32:55.00		1.4594E-02		1.3368E-02	1.8270E+05	1.6807E+05	4.5001E-01	4.9656E-01
08:32:56	08:32:56.00		1.1500E-02		1.2954E-02	1.6158E+05	1.7159E+05	5.1913E-01	4.5276E-01
08:32:57	08:32:57.00		1.2667E-02		1.2966E-02	1.7349E+05	1.6454E+05	5.8920E-01	4.4120E-01
08:32:58			1.4732E-02			1.6154E+05		4.1526E-01	
TOTAL AVERAGES			1.7807E-02			1.7936E+05		5.0372E-01	

ALCOR DERIVED DATA MINIMUM DETECTABLE DBZ AT 1 KILOMETER: -400.00
ACCEPTABLE RANGE OF Z: 1.000000E-04 TO 1.000000E+04

RADAR CORRECTION (IN DB) 0.00

RADAR RUNNING MEAN INTERVAL 5 (SECONDS)

RADAR TIME	AVERAGED TIME	RANGE METERS	AZIMUTH DEGREES	ELEVATION DEGREES	HEIGHT METERS	RADAR DB	ORIGINAL Z	DERIVED Z	REJECTION	MINIMUM DETECT	ICE/WATER ADJUSTMENT	(ADDED IN)
08:32:25	08:32:25.000	54465	117.1380	15.1140	14481	-9.900	.102	.106		0.000	0.00	.16
08:32:26	08:32:26.000	54371	116.9620	15.1470	14480	-9.100	.123	.104		0.000	0.00	.48
08:32:27	08:32:27.000	54254	116.7870	15.1810	14480	-9.500	.112	.108		0.000	0.00	.40
08:32:28	08:32:28.000	54141	115.6130	15.2150	14480	-10.300	.093	.105		0.000	0.00	.19
08:32:29	08:32:29.000	54027	115.4380	15.2490	14480	-9.700	.107	.097		0.000	0.00	.27
08:32:30	08:32:30.000	53913	115.2510	15.2810	14478	-10.600	.087	.094		0.000	0.00	.37
08:32:31	08:32:31.000	53803	116.0830	15.3140	14477	-10.800	.083	.099		0.000	0.00	.36
08:32:32	08:32:32.000	53687	115.9040	15.3470	14476	-10.000	.100	.098		0.000	0.00	.40
08:32:33	08:32:33.000	53575	115.7250	15.3800	14475	-9.300	.116	.096		0.000	0.00	.33
08:32:34	08:32:34.000	53462	115.5450	15.4140	14475	-9.800	.105	.095		0.000	0.00	.41
08:32:35	08:32:35.000	53351	115.3640	15.4480	14475	-11.400	.072	.089		0.000	0.00	.36
08:32:36	08:32:36.000	53241	115.1820	15.4820	14476	-10.900	.081	.076		0.000	0.00	.36
08:32:37	08:32:37.000	53131	114.9970	15.5150	14474	-11.700	.068	.063		0.000	0.00	.51
08:32:38	08:32:38.000	53021	114.8140	15.5480	14474	-12.500	.056	.053		0.000	0.00	.37
08:32:39	08:32:39.000	52913	114.6290	15.5830	14475	-14.500	.036	.041		0.000	0.00	.39
08:32:40	08:32:40.000	52805	114.4430	15.6170	14475	-16.400	.023	.034		0.000	0.00	.42
08:32:41		52697	114.2570	15.6490	14474	-16.700	.012			.000	0.00	.4
08:32:42		52589	114.0700	15.6840	14475	-14.500	.012			.000	0.00	.4

AVERAGE OF ALL THE ACCEPTED Z POINTS: .0325 R.M.S. OF TIME SHIFT: 1.66736E+00 BASED ON TIME SHIFT OF 15.22 SECONDS

D·

PASS 1 LTA035 04 JUL 78 ANALYSIS DATE: 79/08/09
AIRCRAFT TIME: 06:29:16 - 06:32:58 AVERAGING INT: 3 SECOND
RADAR TIME: 06:29:00 - 06:32:37 PROBE: CLOUD + PRECIP
MINIMUM ACCEPTABLE LWC 1.00E-06
MAXIMUM ACCEPTABLE LWC 1.00E-01 RADAR: ALCOR
RADAR OFFSET 15 SECONDS

PARTICLE TYPES BULL-ROSE / BULL-ROSE

CROSS CORRELATION OF AIRCRAFT/RADAR DATA

NUMBER OF SECONDS RADAR IS SHIFTED	-3	-2	-1	0	1	2	3
CORRELATION PERCENTAGE	89.77	90.74	91.25	90.82	89.71	88.28	86.31

MAXIMUM CORRELATION ACHIEVED WITH A RADAR SHIFT OF -1 SECOND(S) 215 POINTS USED

STATISTICAL PARAMTERS FOR THE 214 ACCEPTED POINTS FROM THE 218 POSSIBLE POINTS

PARAMETER	MEAN	STD DEV	MINIMUM	MAXIMUM	SKEWNESS	KURTOSIS	
A/C MK	2.336E+00	5.627E-02	1.888E+00	2.192E+00	-3.054E-01	5.046E-02	GEOMETRIC
A/C LWC	-1.333E+00	2.279E-01	-2.540E+00	-1.579E+00	-7.376E-01	2.561E-01	GEOMETRIC
A/C Z	-1.908E+00	4.005E-01	-3.093E+00	-1.237E+00	-7.524E-01	2.485E-01	GEOMETRIC
A/C NT	5.233E+00	1.413E-01	4.738E+00	5.414E+00	-1.200E+00	1.467E+00	GEOMETRIC
A/C F	-2.982E-01	5.762E-02	-4.148E-01	-1.322E-01	6.514E-01	-2.023E-01	GEOMETRIC
RADAR Z	-1.603E+00	2.859E-01	-2.027E+00	-9.602E-01	6.671E-01	-4.650E-01	GEOMETRIC
A/C MK	1.096E+02	1.399E+01	7.732E+01	1.557E+02	9.795E-02	3.064E-01	ARITHMETIC
A/C LWC	1.317E-02	5.950E-03	2.291E-03	2.635E-02	2.941E-01	-8.645E-01	ARITHMETIC
A/C Z	1.736E-02	1.294E-02	8.177E-04	5.792E-02	9.956E-01	3.866E-01	ARITHMETIC
A/C NT	1.791E+05	4.967E+04	5.470E+04	2.592E+05	-3.868E-01	-5.553E-01	ARITHMETIC
A/C F	5.077E-01	6.967E-02	3.937E-01	7.376E-01	9.303E-01	3.658E-01	ARITHMETIC
RADAR Z	3.179E-02	2.541E-02	9.387E-03	1.096E-01	1.705E+00	1.958E+00	ARITHMETIC

E

```
ASS   1                                             LTA055       04 JUL 78                            ANALYSIS DATE:  79/08/09
IRCRAFT TIME: 08:29:16 - 08:32:38                                                                     AVERAGING INT:   3 SECOND
  RADAR TIME: 08:29:00 - 08:32:37                    PROBE: CLOUD + PRECIP
MINIMUM ACCEPTABLE LWC    1.00E-06
MAXIMUM ACCEPTABLE LWC    1.00E-01                   RADAR: ALCOR
ADAR OFFSET   14 SECONDS
                                              PARTICLE TYPES BULL-ROSE  / BULL-ROSE

 OTTING RADAR Z    VERSUS A/C  Z
/C  Z  =  1.22040E+00 (RADAR Z) +  4.79532E-02       WITH AN RMS =  1.96698E-01
DAR Z =  5.21795E-01 (A/C  Z ) + -4.15293E-01       WITH AN RMS =  2.25801E-01

OR (USING THE ANTILOG FORM)
                                 1.22040E+00
/C  Z  =  4.79532E-02 (RADAR Z)                      CORRELATION:   87.11 PER CENT
======================================================================================

LOTTING A/C  Z     VERSUS A/C  MK
/C  MK =  3.64923E-02 (A/C  Z ) +  2.10591E+00       WITH AN RMS =  5.43372E-02
/C  Z  =  1.54912E+00 (A/C  MK) + -5.67319E+00       WITH AN RMS =  2.09177E-01

OR (USING THE ANTILOG FORM)
                                 3.64923E-02
/C  MK =  2.10591E+00 (A/C  Z )                      CORRELATION:   25.98 PER CENT
======================================================================================

LOTTING RADAR Z    VERSUS A/C  MK
/C  MK =  5.48552E-02 (RADAR Z) +  2.14023E+00       WITH AN RMS =  5.31259E-02
ADAR Z =  1.67437E+00 (A/C  MK) + -5.01209E+00       WITH AN RMS =  1.61216E-01

OR (USING THE ANTILOG FORM)
                                 5.48552E-02
/C  MK =  2.14023E+00 (RADAR Z)                      CORRELATION:   32.95 PER CENT
======================================================================================

LOTTING A/C  Z     VERSUS A/C  NT
/C  NT =  3.11569E-01 (A/C  Z ) +  5.82731E+00       WITH AN RMS =  6.75167E-02
/C  Z  =  2.43241E+00 (A/C  NT) + -1.49575E+01       WITH AN RMS =  7.67587E-02

OR (USING THE ANTILOG FORM)
                                 3.11569E-01
/C  NT =  5.82731E+00 (A/C  Z )                      CORRELATION:   87.96 PER CENT
======================================================================================

LOTTING RADAR Z    VERSUS A/C  NT
/C  NT =  3.70386E-01 (RADAR Z) +  5.82627E+00       WITH AN RMS =  9.44934E-02
ADAR Z =  1.50306E+00 (A/C  NT) + -9.46767E+00       WITH AN RMS =  1.26644E-01

OR (USING THE ANTILOG FORM)
                                 3.70386E-01
/C  NT =  5.82627E+00 (RADAR Z)                      CORRELATION:   74.61 PER CENT
======================================================================================
```

PASS 1
AIRCRAFT TIME: [illegible]
RADAR TIME: [illegible]
MINIMUM ACCEPTABLE [illegible]
MAXIMUM ACCEPTABLE [illegible]
RADAR OFFSET [illegible] SECONDS

PLOTTING A/C [illegible]
A/C F = [illegible]
A/C Z = [illegible]

OR (USING THE ANT[illegible]

A/C F = [illegible]

PLOTTING RADAR [illegible]
A/C F = [illegible]
RADAR Z = [illegible]

OR (USING THE ANT[illegible]

A/C F = [illegible]

PLOTTING A/C Z [illegible]
A/C LWC = [illegible]
A/C Z = [illegible]

OR (USING THE ANT[illegible]

A/C LWC = [illegible]

PLOTTING RADAR [illegible]
A/C LWC = [illegible]
RADAR Z = [illegible]

OR (USING THE ANT[illegible]

A/C LWC = [illegible]

PASS 1 LTA055 04 JUL 78 ANALYSIS DATE: 79/08/09
AIRCRAFT TIME: 08:29:16 - 08:32:58 AVERAGING INT: 3 SECOND
RADAR TIME: 08:29:00 - 08:32:37 PROBE: CLOUD + PRECIP
MINIMUM ACCEPTABLE LWC 1.00E-06
MAXIMUM ACCEPTABLE LWC 1.00E-31 RADAR: ALCOR
RADAR OFFSET 14 SECONDS
PARTICLE TYPES BULL-ROSE / BULL-ROSE

PLOT A/C Z AND RADAR Z VERSUS TIME

PLOT A/C MK AND RADAR Z VERSUS TIME

PLOT A/C NT AND RADAR Z VERSUS TIME

PLOT A/C F AND RADAR Z VERSUS TIME

PLOT A/C LWC AND RADAR Z VERSUS TIME

******* END OF PASS 1 *******

H

2.2.1.2 Program RAPP Operating Instructions

RAPP CONTROL CARDS

```
JOBNN,CM110000,T200,NT1,TP1.        ACT#       NAME
VSN,TAPE1=TAPEXX/NT.  (TAPE2 IN HAIC1D OR KNOLL1D)
REQUEST,TAPE1,NT,E,NORING.
VSN,TAPE3=TAPENO.  (RADAR DATA TAPE)
REQUEST,TAPE3,NORING,MT.
ATTACH,CRT,CRTPLOTS,MR=1.
LIBRARY,CRT.
REQUEST,TAPE39,*Q.
DISPOSE,TAPE39,*FM.
ATTACH,LGO,RAPPBIN,ID=GLASS,MR=1.
LDSET,PRESET=ZERO.
LGO.
EXIT(U)
CATALOG,TAPE10,FILENAME,ID=PFID.*
7/8/9
-DATA HEADER CARD-
-DBZ REJECT CARDS (OPTIONAL)
-COMMENT CARD 1-
-COMMENT CARD 2-
-PASS CARDS-
6/7/8/9
*OPTIONAL - TAPE1 IN PROGRAM RADMCOM
```

2.2.1.2 Program RAPP Operating Instructions (cont'd)

CARD 1 HEADER CARD

CC 1 AIRCRAFT IDENTIFIER
- 1 C138-E AIRCRAFT
- 2 LEAR AIRCRAFT
- 3 C138-A AIRCRAFT

CC 3 RADAR IDENTIFIER
- 0 SPANDAR RADAR
- 1 ALCOR RADAR
- 2 TRADEX RADAR

CC 5-14 FLIGHT DATE (USED FOR FILM IDENTIFICATION)

CC 16 PROBE SELECTED
- 1 SCATTER PROBE
- 2 CLOUD PROBE
- 3 PRECIP PROBE
- 4 TOTAL (AS GIVEN BY KNOLL1D)

CC 21-30 RADAR OFFSET DISTANCE IN METERS (USUALLY 3000 FOR KWAJALEIN

CC 31-40 RADAR CORRECTION (GIVEN IN DB)

CC 41-50 MINIMUM DETECTABLE RADAR SIGNAL GIVEN AT 1 KILOMETER (IN DB UNITS)

CC 53
- 0 IF THERE IS RADAR DATA (DEFAULT)
- 1 FOR AIRCRAFT DATA ONLY

2.2.1.2 Program RAPP Operating Instruction (cont'd)

CC 55   0   USE STANDARD AIRCRAFT CLOCK (DEFAULT)

1   USE THE PMS BUFFER GENERATED TIME

CC 57   FORMAT OF RADAR TAPE

0   DATA IS IN FORMAT GIVEN BY PROGRAM SPANDAR (DEFAULT)

1   TAPE IS IN MOIST GENERATED FORMAT - USE FIRST RADAR ON THE RADAR TAPE

2   TAPE IS IN MOIST GENERATED FORMAT - USE SECOND RADAR ON THE RADAR TAPE

CC 61-65   AVERAGING INTERVAL FOR THE AIRCRAFT RUNNING MEAN

CC 66-70   AVERAGING INTERVAL FOR THE RADAR RUNNING MEAN

CC 71-75   NUMBER DBZ REJECTION CARDS (10 MAXIMUM)

CARDS #2-N+1   WHERE N IS THE NUMBER GIVEN IN COLUMN 75 OF CARD 1 (OPTIONAL)

CC 1-10   DBZ LOWER LIMIT (FLOATING)

CC 11-20   DBZ UPPER LIMIT (FLOATING)

CC 21-30   PP-OP VALUE (FLOATING)

CARDS # N+2, N+3 COMMENT CARDS

COLUMNS 1-42 OF EACH OF THESE CARDS CAN CONTAIN ANY TEXT. THIS COLUMN WILL BE PLACED ON THE TOP TWO LINES OF EACH

2.2.1.2 Program RAPP Operating Instructions (cont'd)

MICROFICHE IN VERY LEGIBLE LETTERS--READABLE TO THE UNAIDED EYE. THESE TWO CARDS ARE ALSO PRINTED ON THE OUTPUT.

CARDS #N+4-N+K+3 WHERE K IS THE NUMBER OF DESIRED TIME FRAMES

CC 1-2 PASS NUMBER

CC 4-9 PASS START TIME IN FORM HHMMSS.

CC 11-16 PASS STOP TIME IN FORM HHMMSS.

CC 21-30 SECONDARY RADAR CORRECTION

CC 31-40 MINIMUM ACCEPTABLE LIQUID WATER CONTENT (IN GM/M**3)

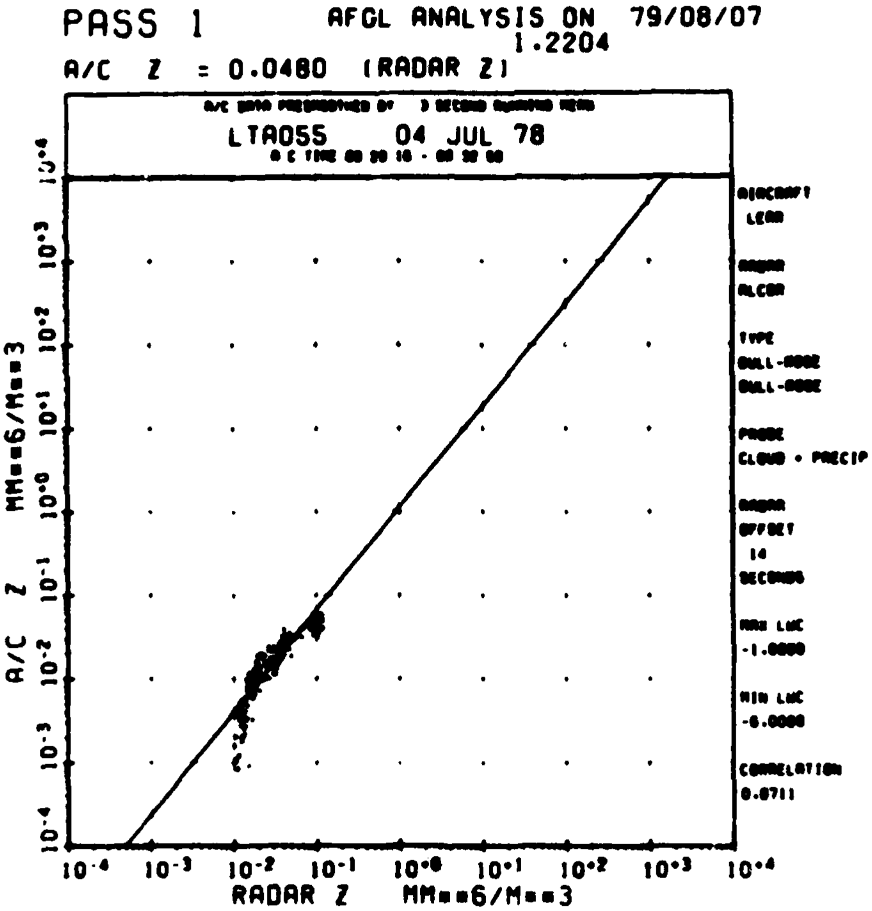
CC 41-50 MAXIMUM LIQUID WATER CONTENT (SEE 31-40)

CC 51-60 MINIMUM ACCEPTABLE Z VALUES (IN Z UNITS)

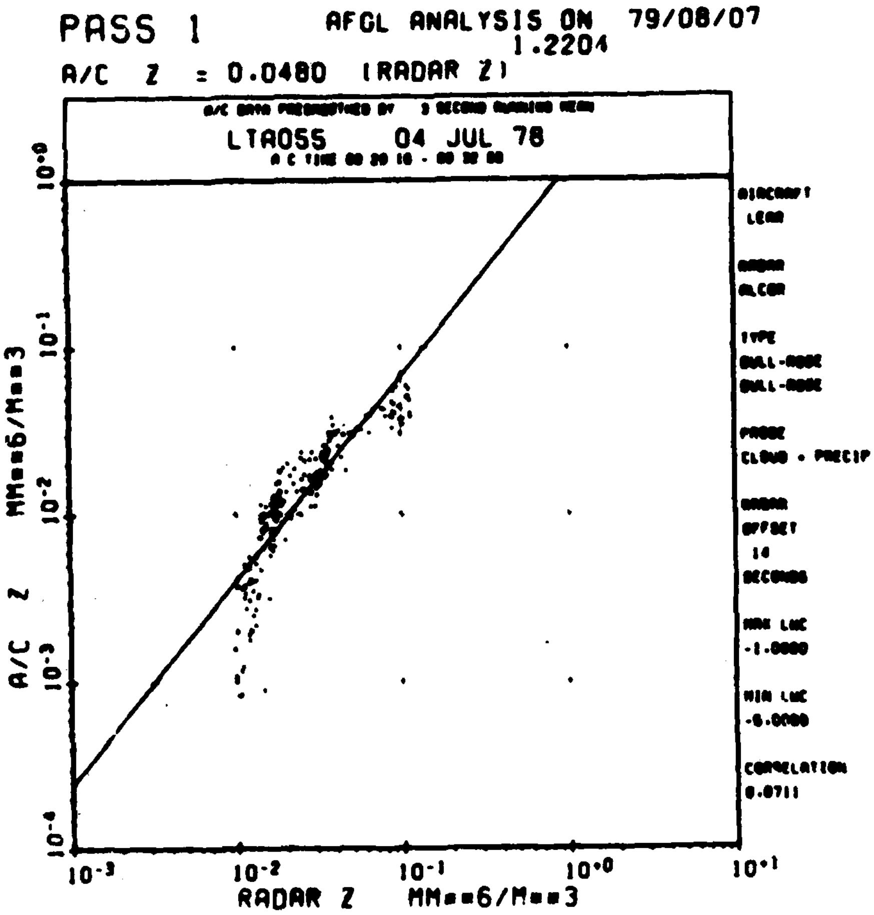
CC 61-70 MAXIMUM Z VALUE (IN Z UNITS)

AN IMPORTANT NOTE TO REMEMBER IS THAT THE TIMES INPUT FOR THIS VERSION OF RAPP PERTAIN TO AIRCRAFT START AND STOP TIMES.

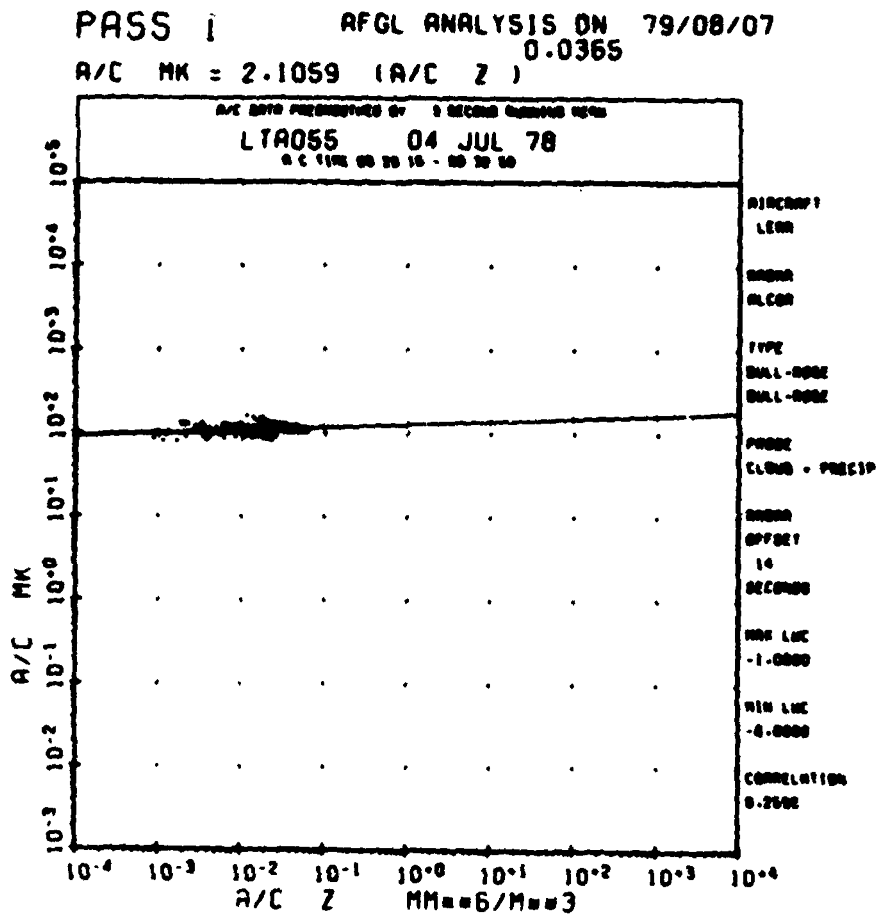
2.2.1.3 RAPP sample plots



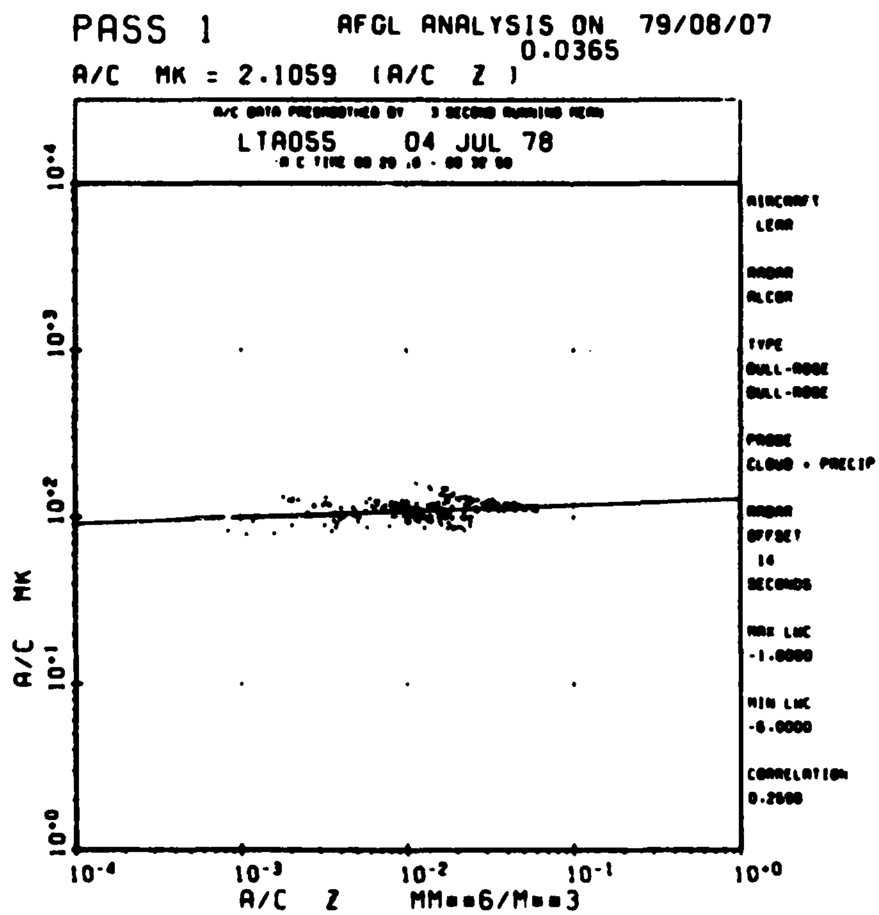
2.2.1.3 RAPP sample plots (cont'd)



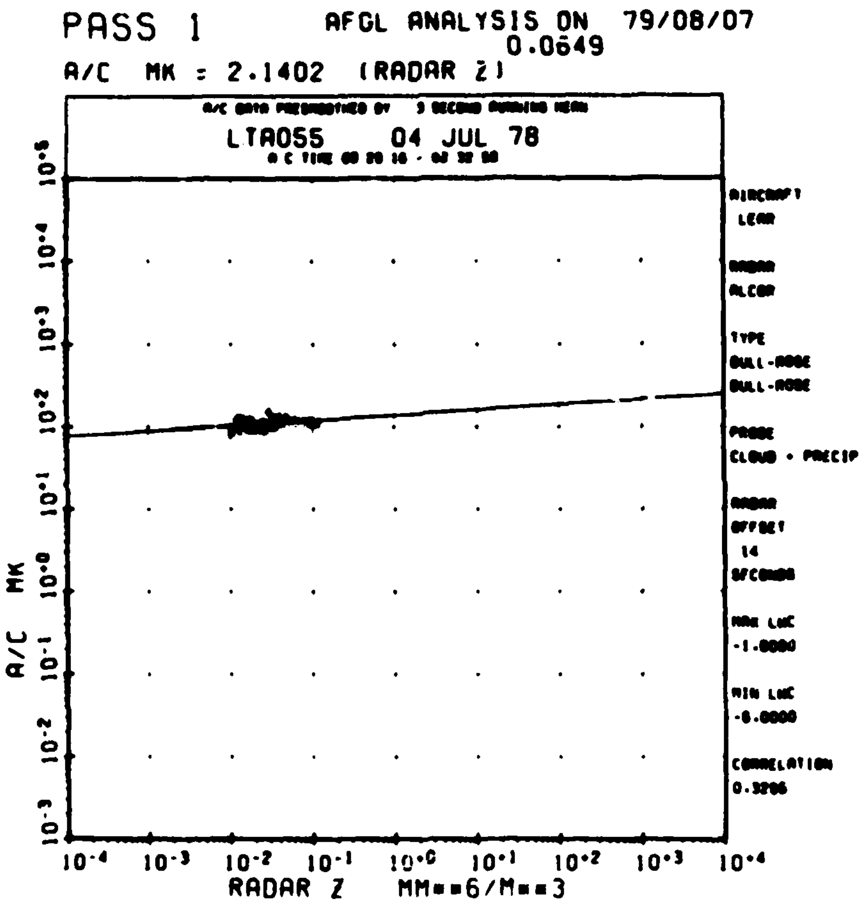
2.2.1.3 RAPP sample plots (cont'd)



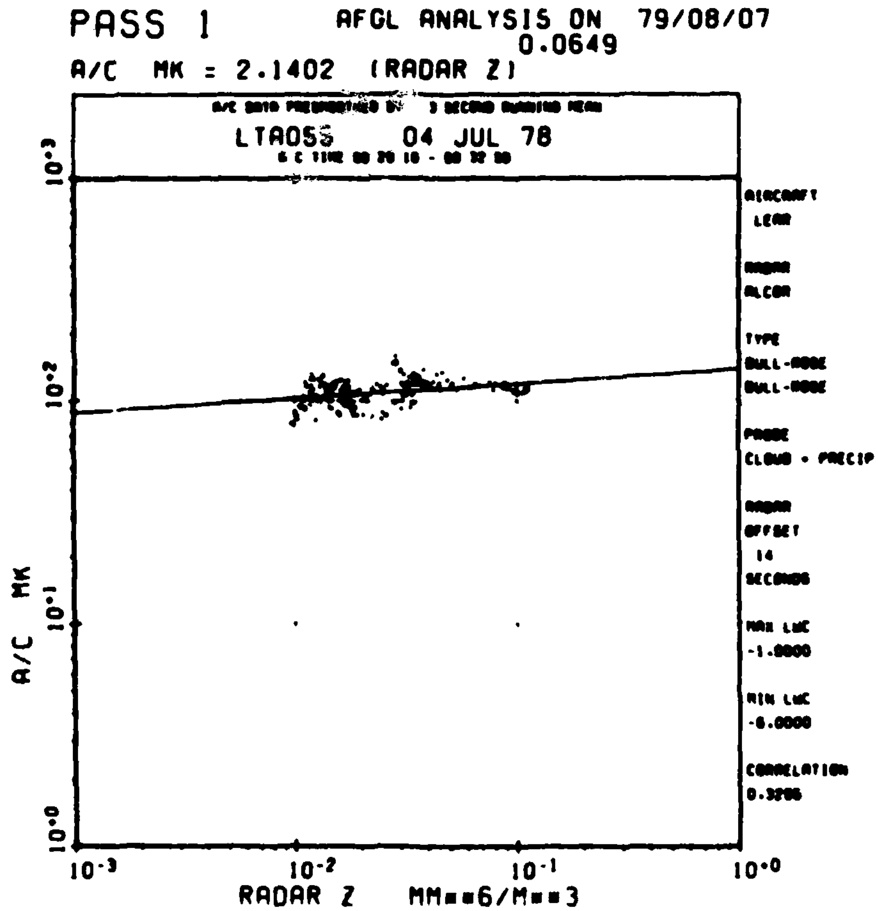
2.2.1.3 RAPP sample plots (cont'd)



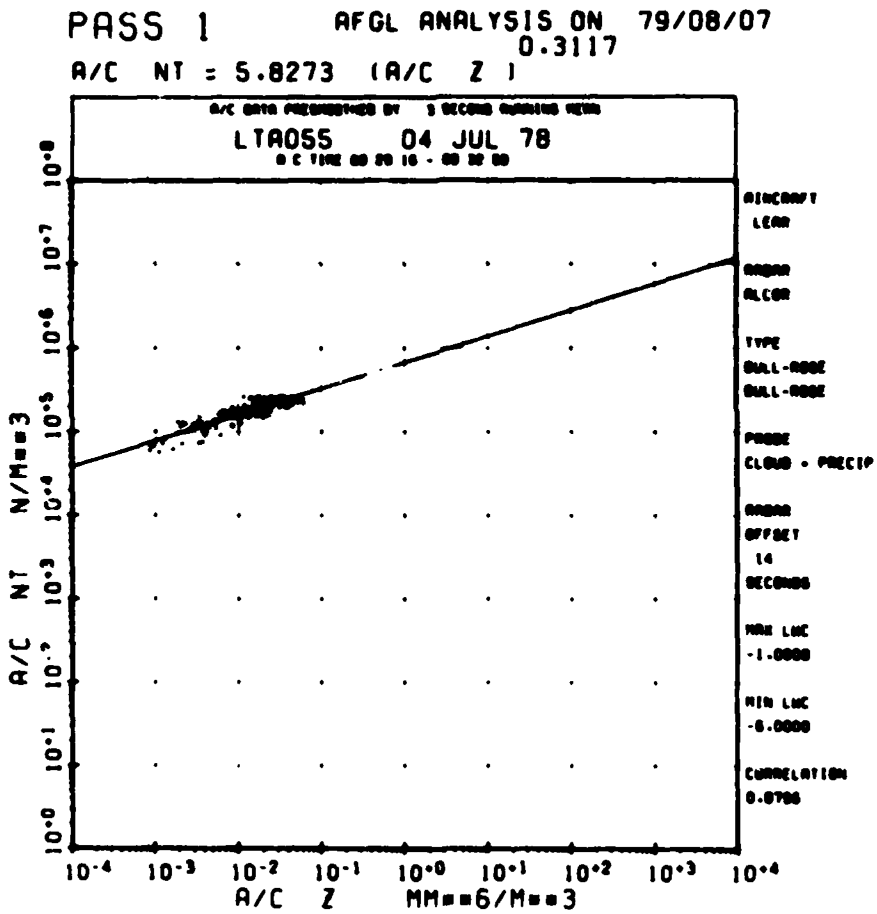
2.2.1.3 RAPP sample plots (cont'd)



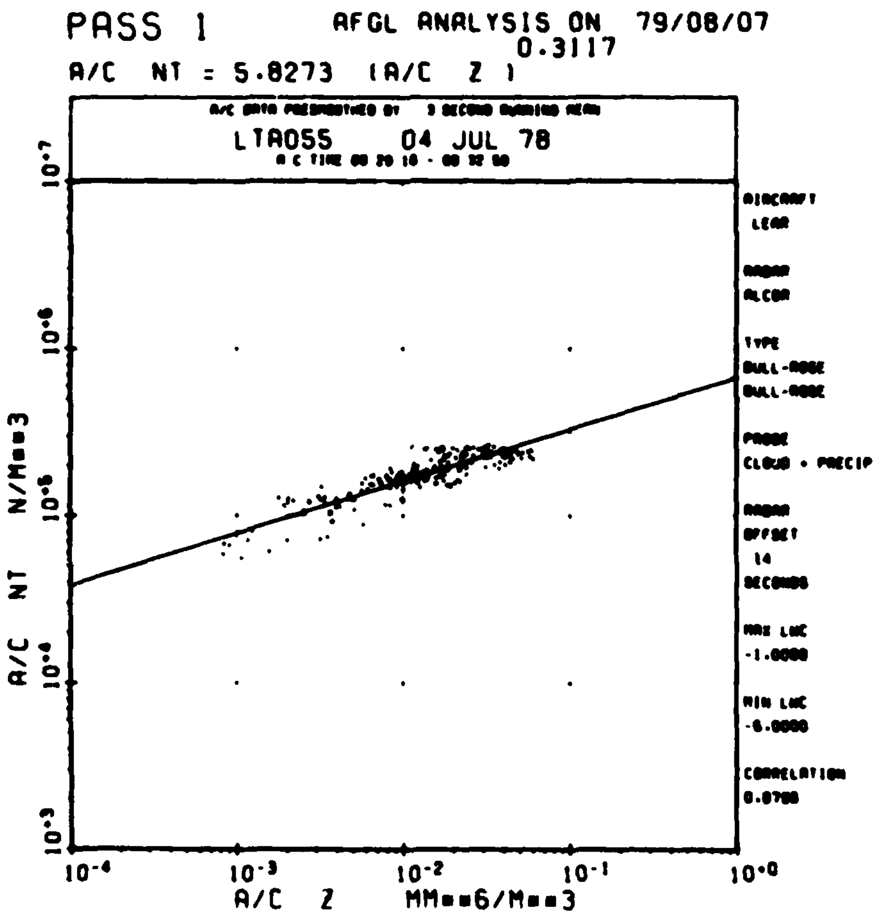
2.2.1.3 RAPP sample plots (cont'd)



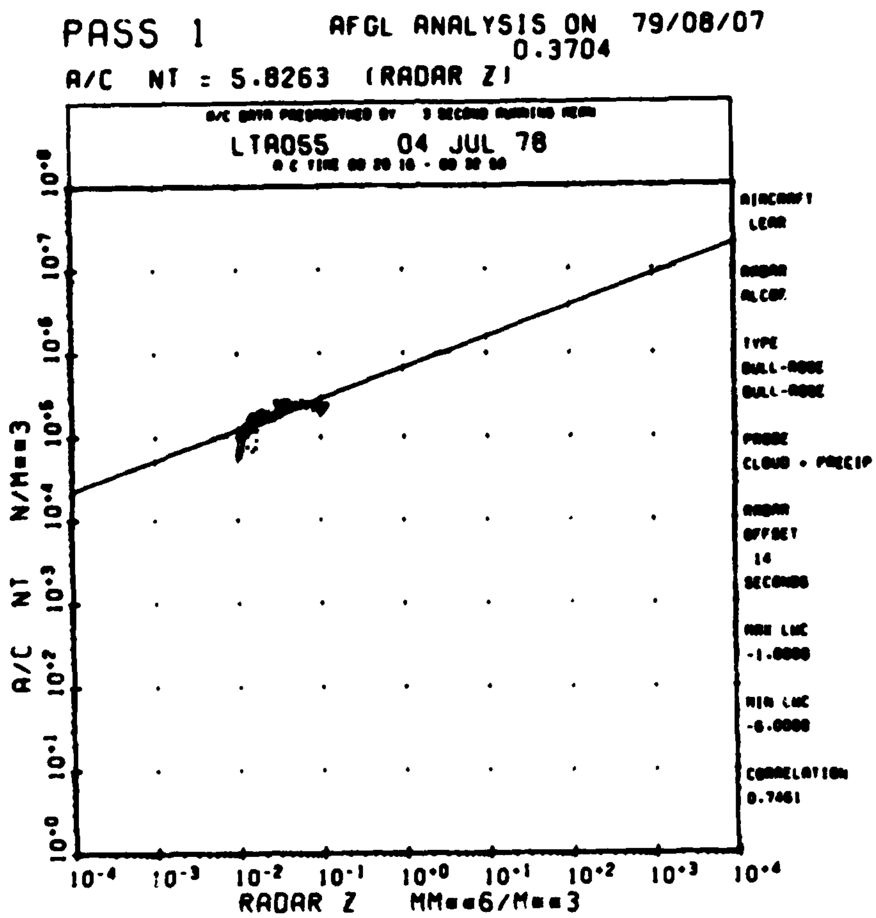
2.2.1.3 RAPP sample plots (cont'd)



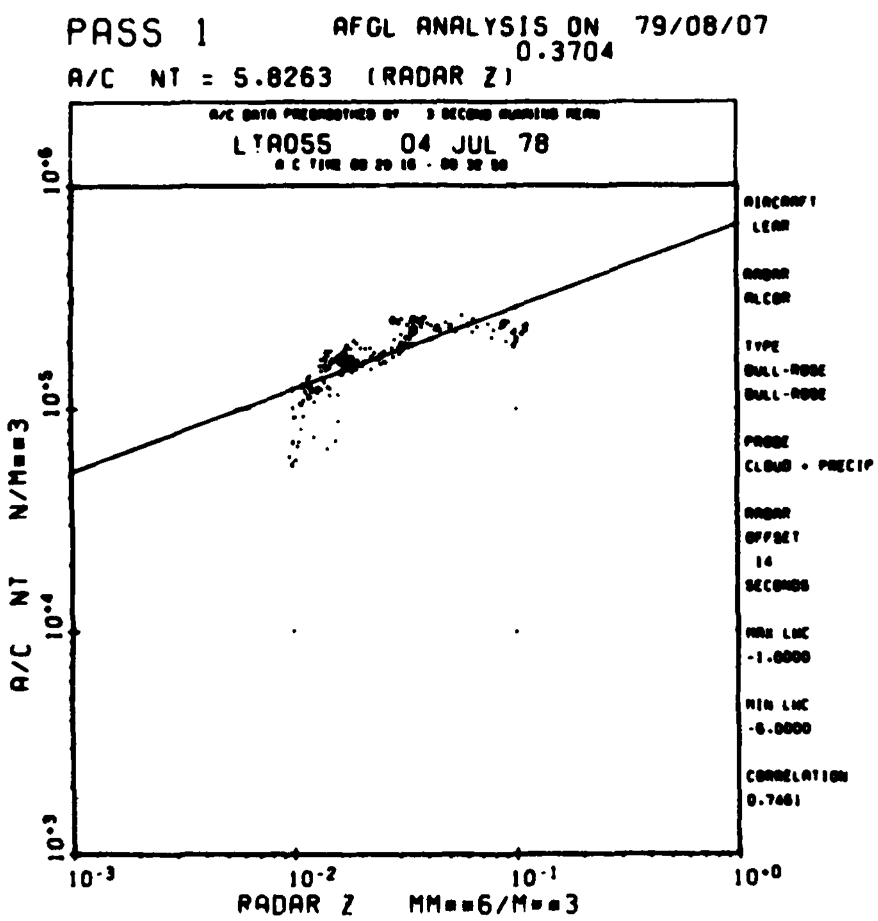
2.2.1.3 RAPP sample plots (cont'd)



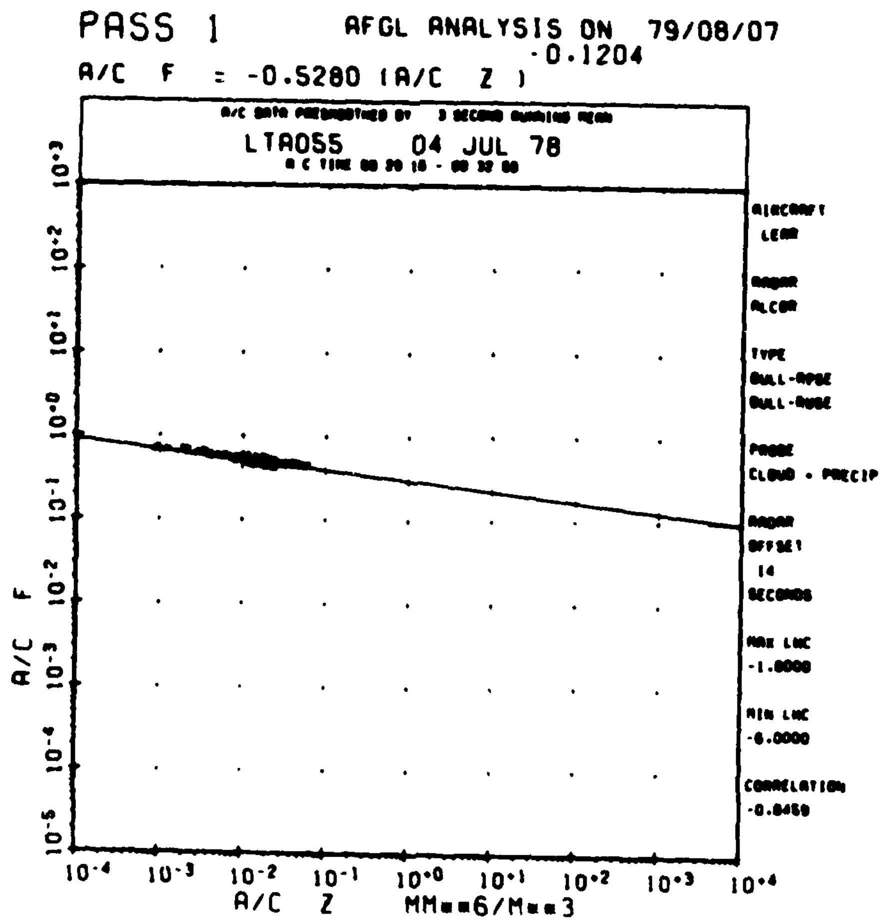
2.2.1.3 RAPP sample plots (cont'd)



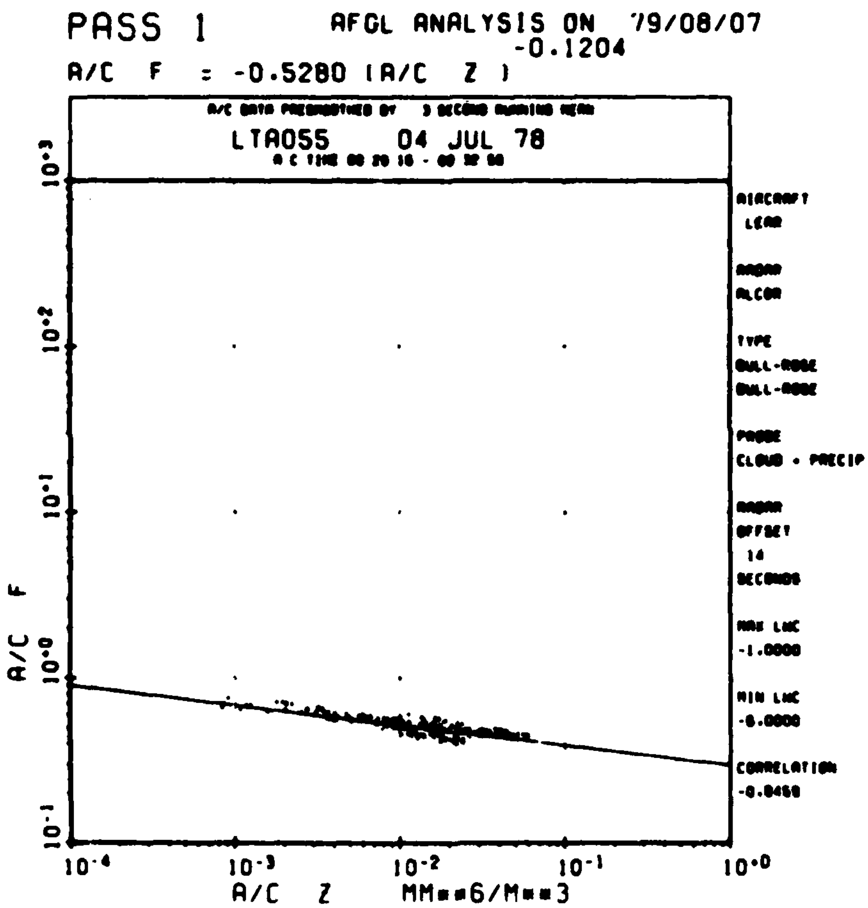
2.2.1.3 RAPP sample plots (cont'd)



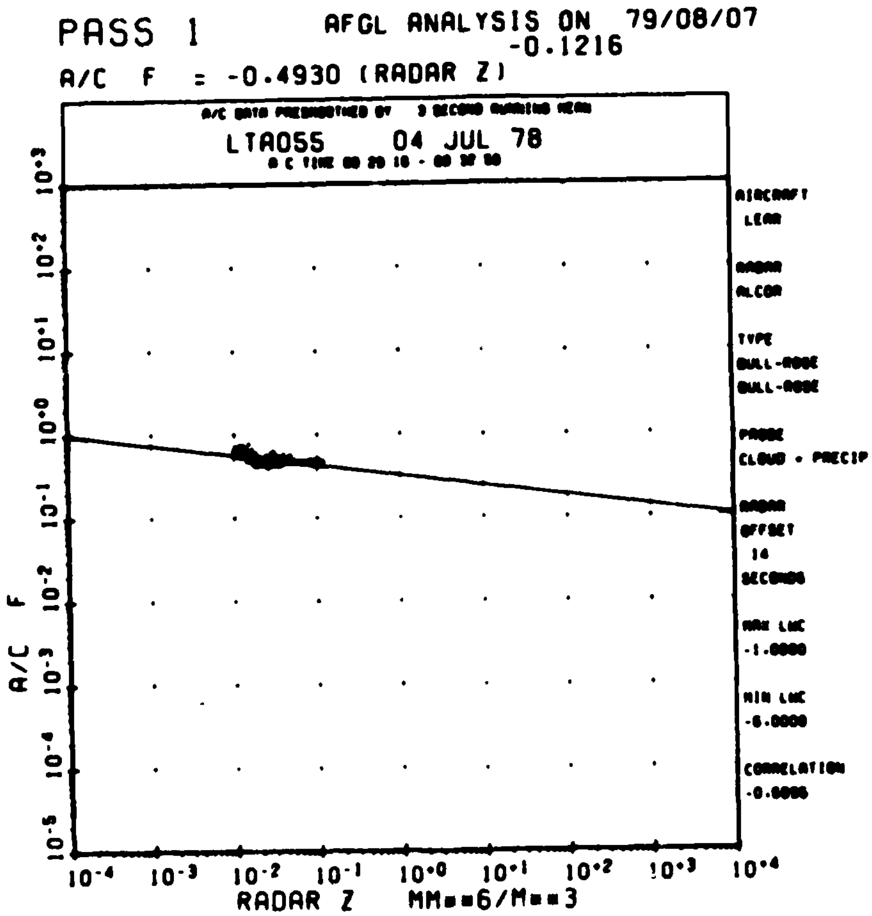
2.2.1.3 RAPP sample plots (cont'd)



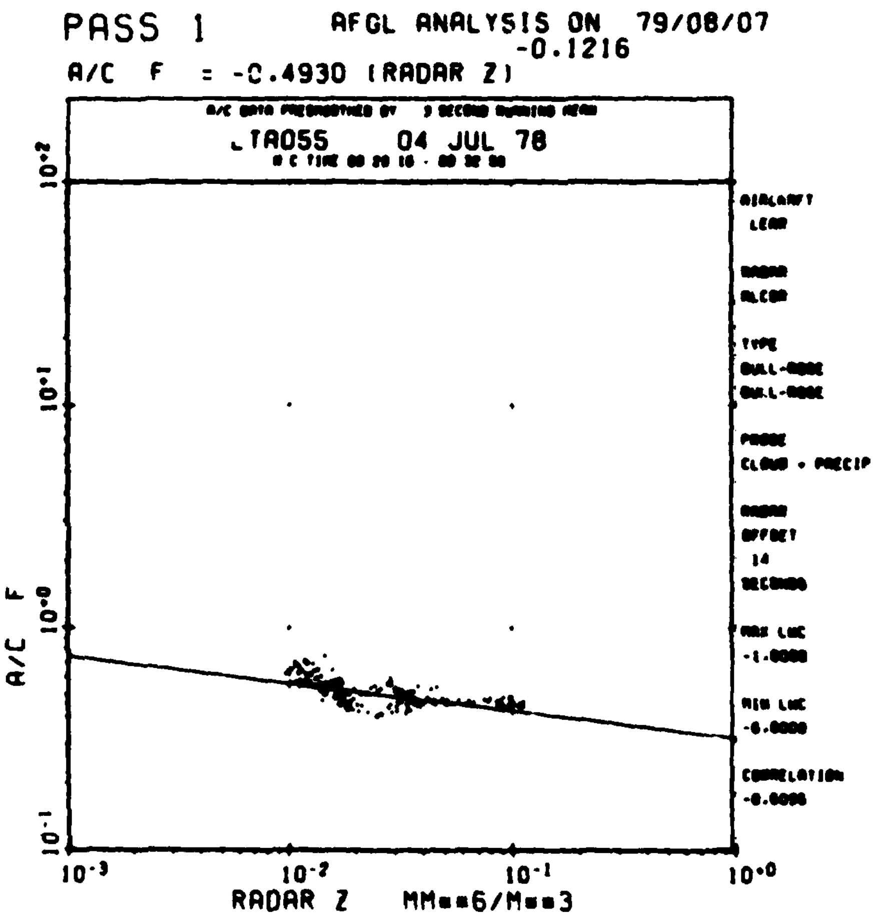
2.2.1.3 RAPP sample plots (cont'd)



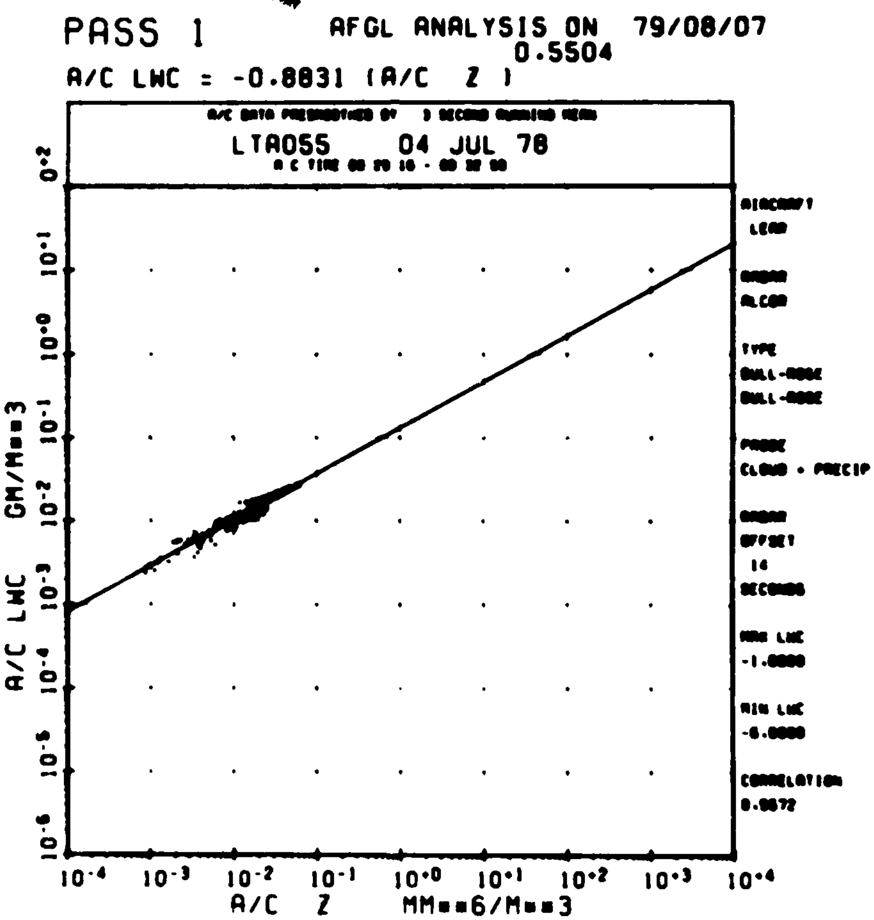
2.2.1.3 RAPP sample plots (cont'd)



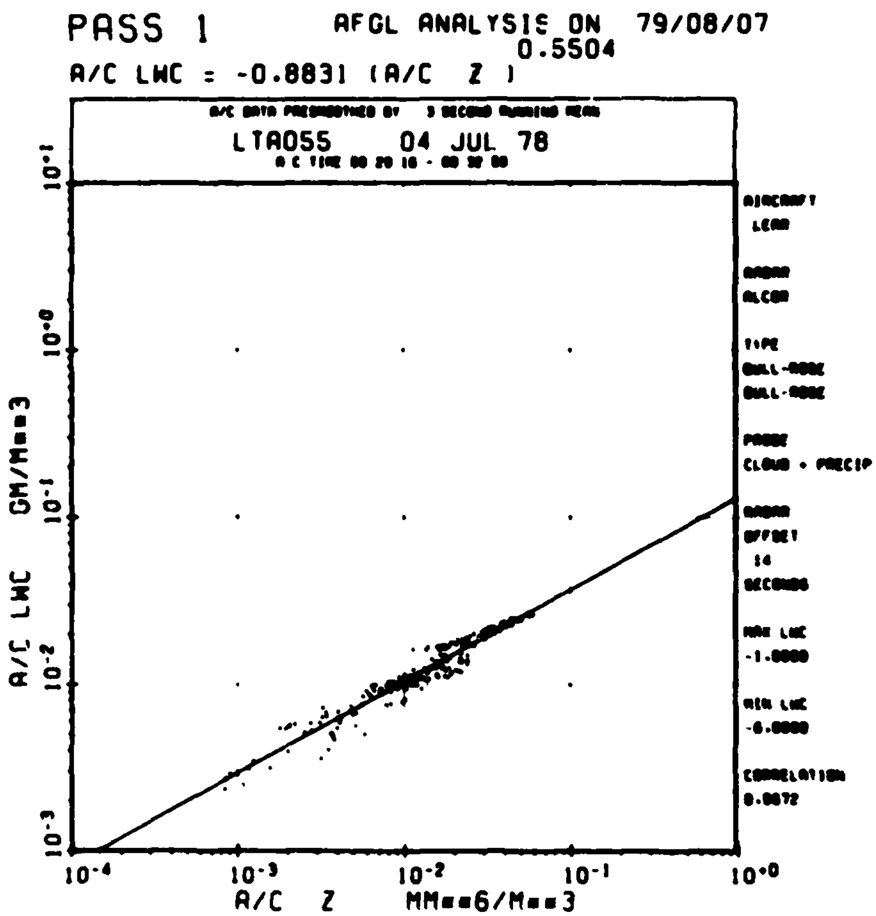
2.2.1.3 RAPP sample plots (cont'd)



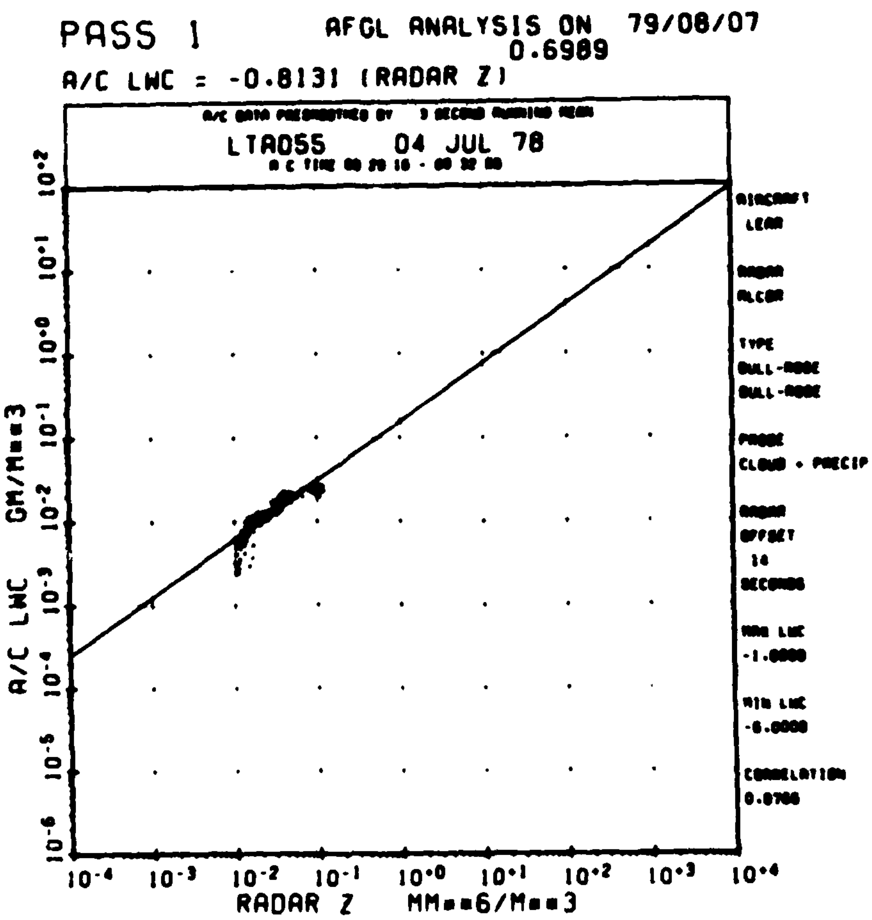
2.2.1.3 RAPP sample plots (cont'd)



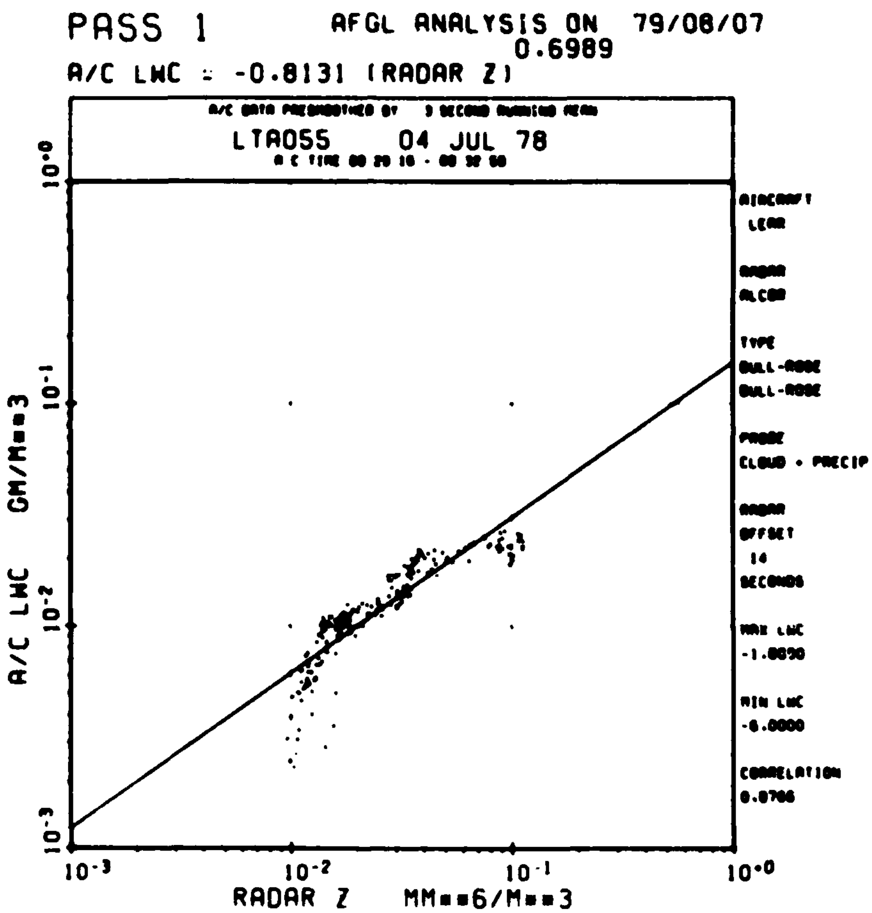
2.2.1.3 RAPP sample plots (cont'd)



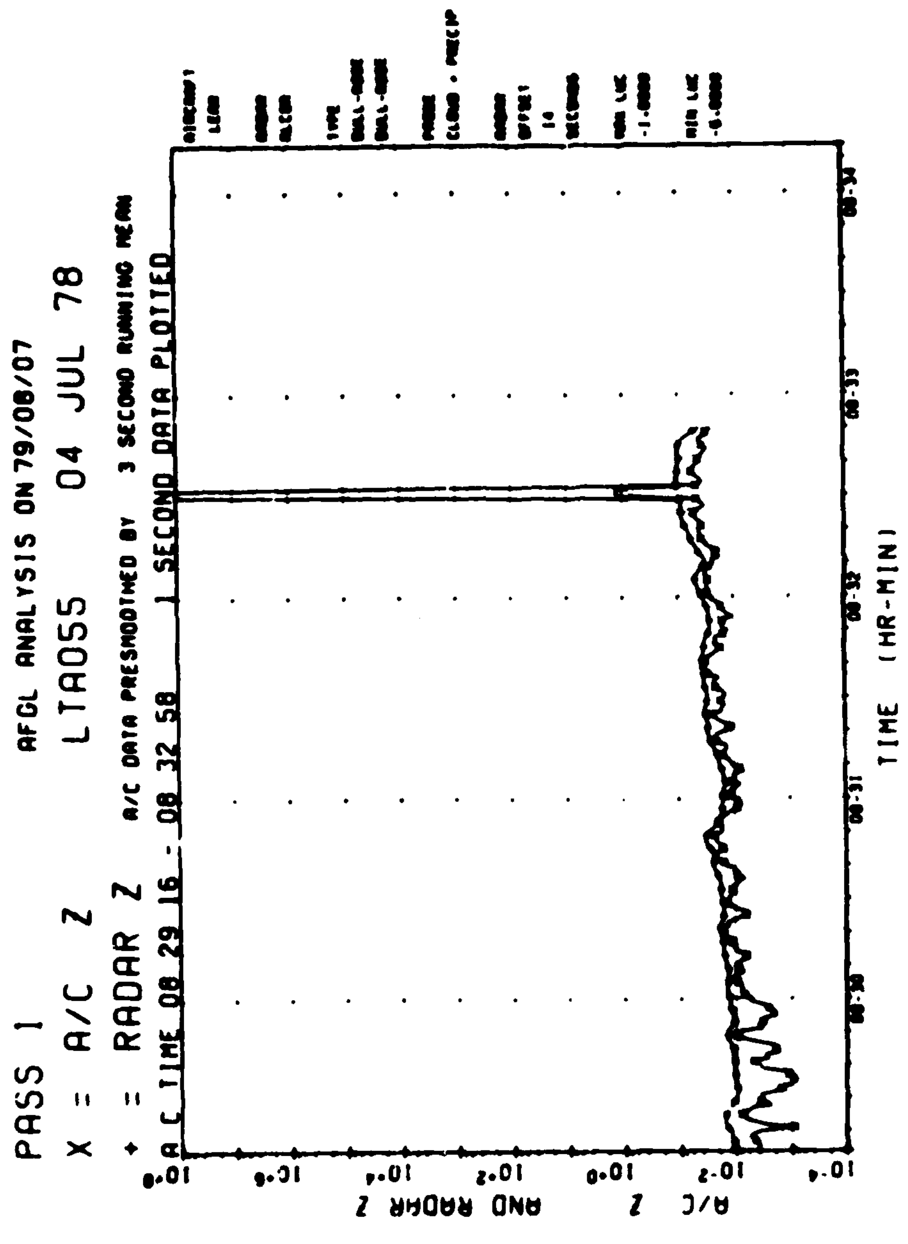
2.2.1.3 RAPP sample plots (cont'd)



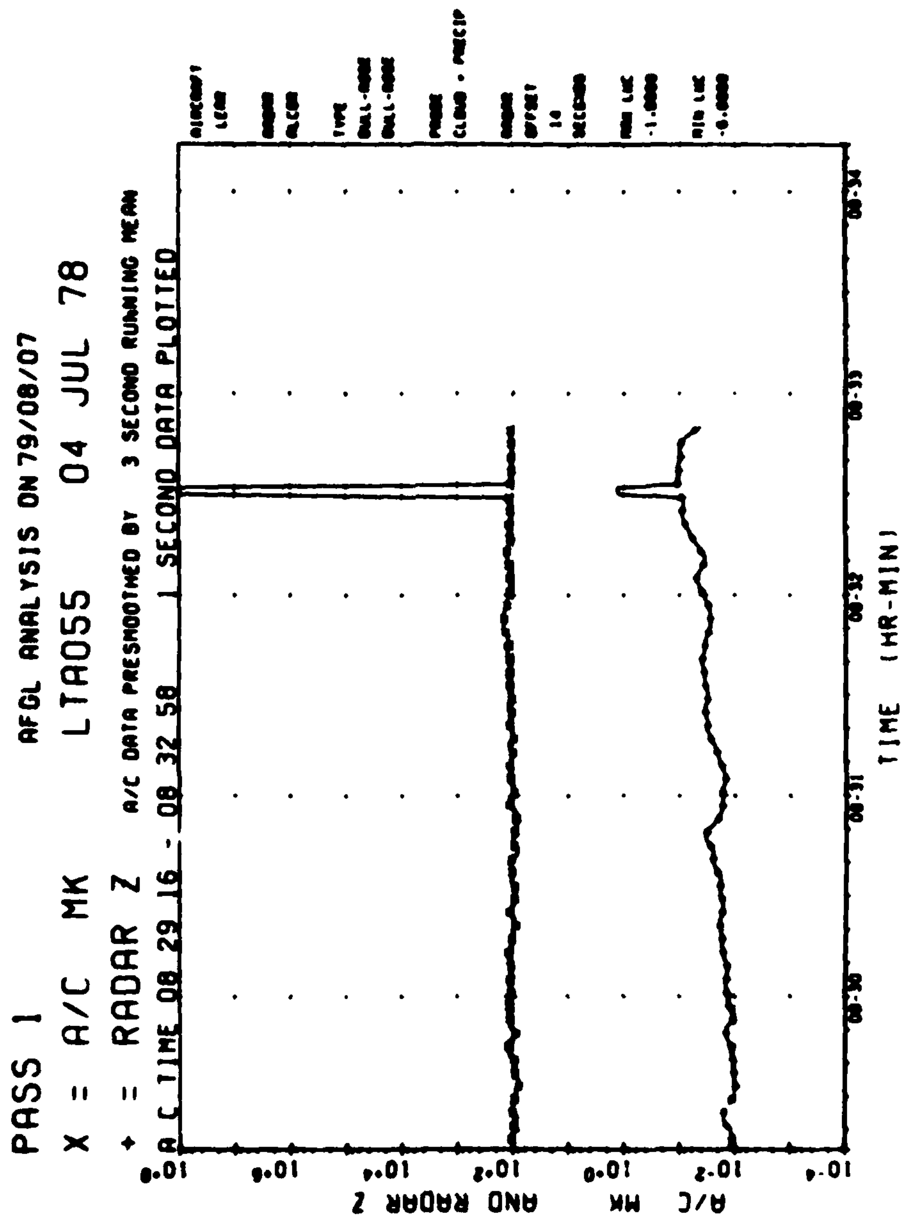
2.2.1.3 RAPP sample plots (cont'd)



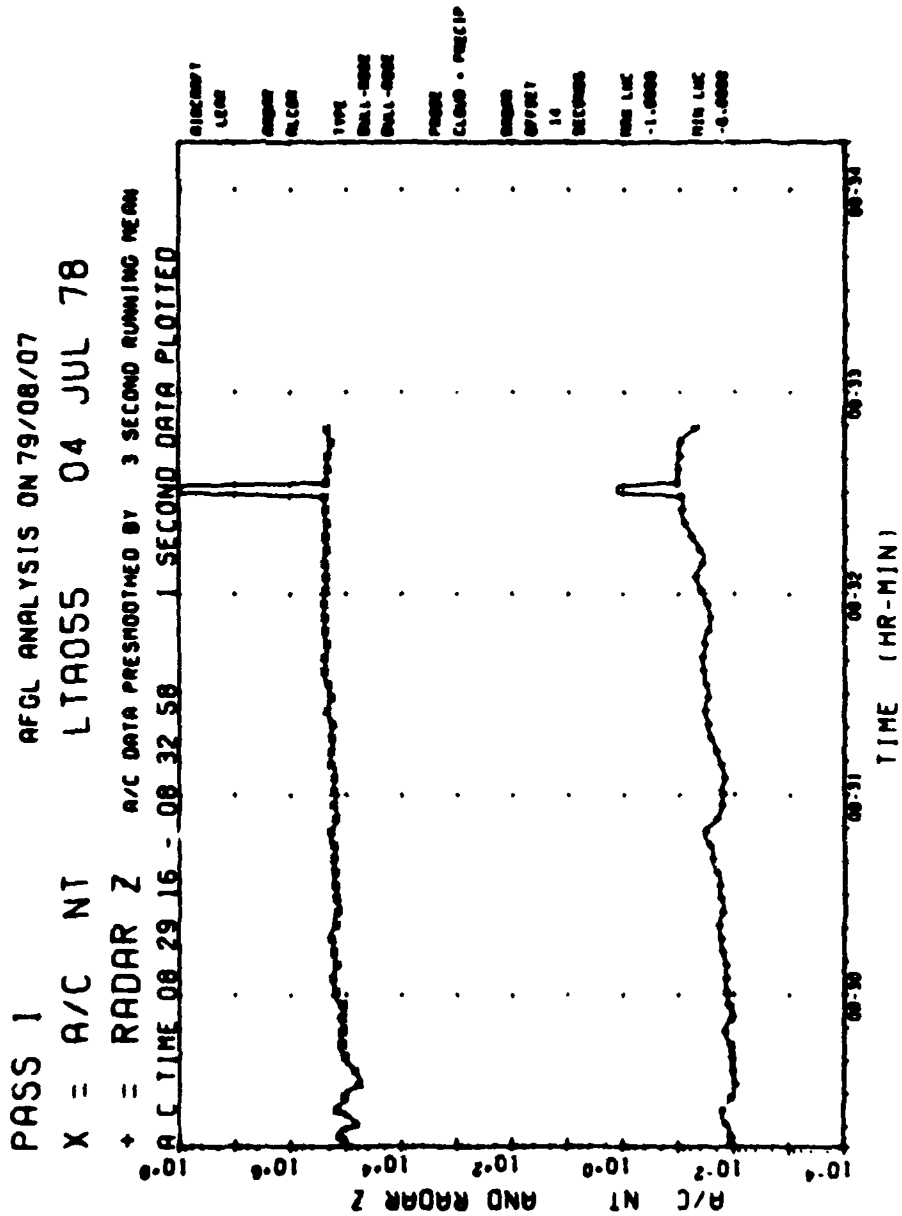
2.2.1.3 RAPP sample plots (cont'd)



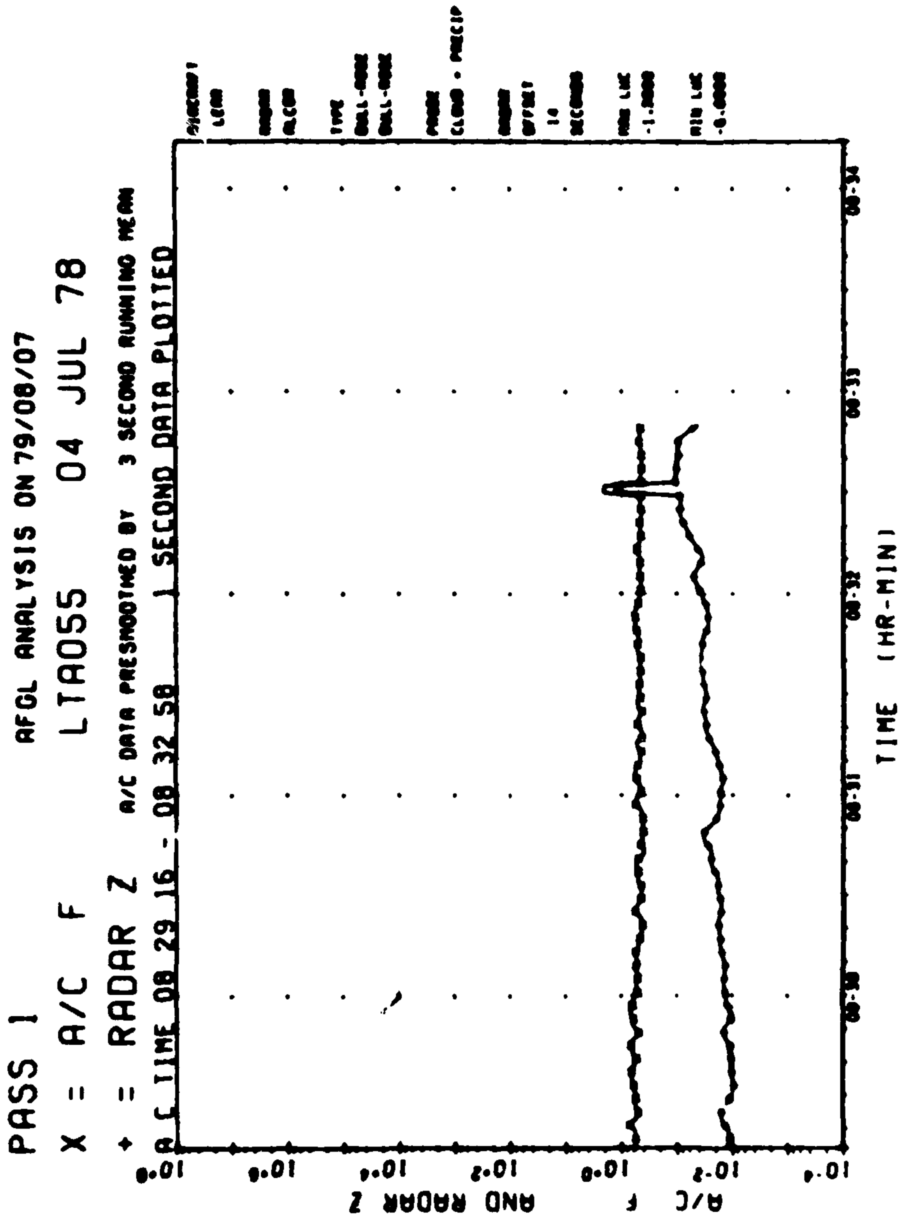
2.2.1.3 RAPP sample plots (cont'd)



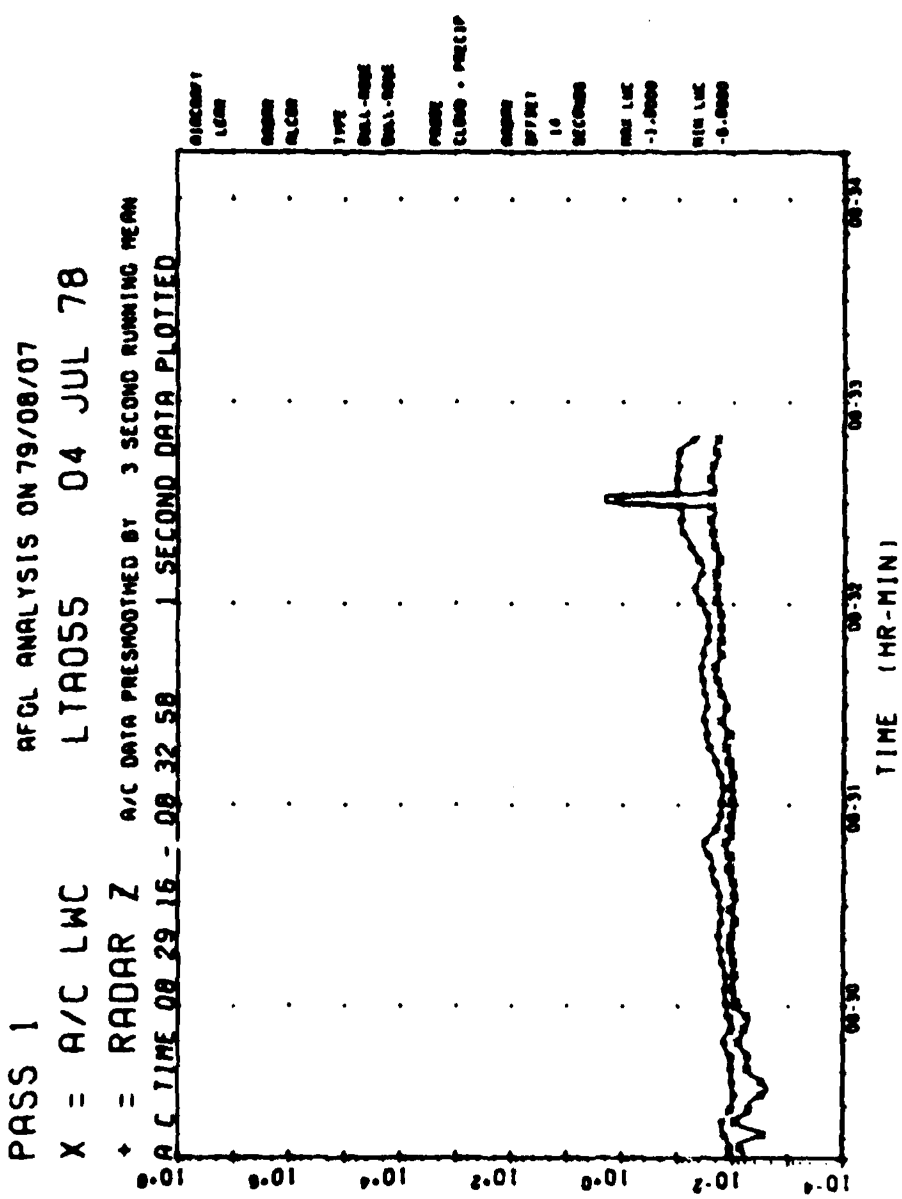
2.2.1.3 RAPP sample plots (cont'd)



2.2.1.3 RAPP sample plots (cont'd)



2.2.1.3 RAPP sample plots (cont'd)



2.2.2 Program RADMCOM

RADMCOM has been written for the purpose of comparing three methods of calculating LWC from radar Z with the standard method now used in RAPP.

RADMCOM accepts the following paramters for each pass:

1) PASS
2) A
3) B
4) KC
5) KP
6) MBAR

The PASS corresponds to the pass number used in program RAPP; It is used to find the correct data on the input tape - tape 1 (tape 10 in RAPP). A, B are used to calculate RADAR LWC for each record in the pass in the following manner:

$$\text{LWC} = \text{A} * (\text{RADAR Z})^{\text{B}} \quad \text{(METHOD 1)}$$

KC and KP are used to calculate LWC also,

$$\text{LWC} = \text{KC} * (\text{RADAR Z})^{.5} \quad \text{(METHOD 2)}$$

$$\text{LWC} = \text{KP} * (\text{RADAR Z})^{.5} \quad \text{(METHOD 3)}$$

MBAR is the average LWC for the pass in RAPP. One second differences of the RAPP produced LWC values to the mean are derived.

RADMCOM simply calculates and reports the above calculated

2.2.2 Program RADMCOM (cont'd)

LWC values, along with the RAPP produced one's, for every second. LWC means and standard deviations are then reported for the pass. Complete documentation can be seen on the following pages.

2.2.2.1 Program RADMCOM operating instructions

RADCMCOM compares the methods of calculating LWC from Radar Z with the standard method of program RAPP.

OPERATING INSTRUCTIONS

CONTROL CARDS

```
DPSI,CM40000,T250             ID#        NAME
ATTACH,LGO,RADMCOMBIN,ID=GLASS,MR=1.
ATTACH,TAPE1,DATAFILENAME,ID=NAME,MR=1.
LGO.
7/8/9
```

DATA CARDS (AS MANY AS NEEDED IN TIME ORDER)

```
 COL
 1-2      PASS NO(I2 FORMAT)
11-20     A    (F10.4 FORMAT)
21-30     B    (F10.4 FORMAT)
31-40     KC   (F10.4 FORMAT)
41-50     KP   (F10.4 FORMAT)
51-60     MBAR (F10.4 FORMAT)
6/7/8/9
```

NOTE

```
PASS NO IS THE PASS NUMBER USED IN THE PREVIOUS RAPP RUN
LWC = A*(RAD Z)**(B)          (METHOD 1)
LWC = KC*(RAD Z)**(.5)        (METHOD 2)
LWC = KP*(RAD Z)**(.5)        (METHOD 3)
MBAR= AVERAGE RADAR LWC FROM RAPP
```

2.2.2.1 Program RADMCOM operating instructions (cont'd)

TAPE 1 FORMAT (TAPE 10 FROM RAPP)

END-OF-FILE MARKER
PASS DATA SECTION*
END-OF-FILE MARKER
PASS DATA SECTION*
END-OF-FILE MARKER
.
.
.
END-OF FILE MARKER

* DATA SECTION
HEADER RECORD**
DATA RECORDS***
.
.
DATA RECORDS***

** HEADER RECORD FORMAT
WORD 1 FLIGHT ID - A10 FORMAT
WORD 2 FLIGHT DATE - A10 FORMAT
WORD 3 PASS# - INTEGER FORMAT
WORD 4 START TIME OF PASS - INTEGER SECONDS
WORD 5 STOP TIME OF PASS - INTEGER SECONDS

*** DATA RECORD FORMAT
WORD 1 TIME IN SECONDS
WORD 2 A/C MK - REAL FORMAT
WORD 3 RADAR Z - REAL FORMAT
WORD 4 RADAR M - REAL FORMAT

2.2.2.2 RADMCOM sample output

On the following two pages are RADMCOM sample output.

PASS 13 FLT 577-12 13 JAN 77 0315 138 TO 03:55:58 PAGE 6

	RAJAN M (FAD M-MBAR)	M=A*ZR**.5(DELTA M)	M=KC*ZR**.5(DELTA M)	M=KP*ZR**.5(DELTA M)
03:54:49	5.181E-02(-5.4.9E-02)	7.475E-02(-1.294E-02)	7.184E-02(-1.103E-02)	5.469E-02(7.124E-03)
03:54:50	6.763E-02(-5.237E-02)	7.415E-02(-1.092E-02)	7.102E-02(-7.388E-03)	5.406E-02(9.564E-03)
03:54:51	6.596E-02(-5.0[illegible]E-02)	7.415E-02(-8.191E-03)	7.102E-02(-5.059E-03)	5.406E-02(1.189E-02)
03:54:52	6.[illegible]78E-02(-5.132E-02)	7.415E-02(-9.374E-03)	7.102E-02(-6.241E-03)	5.406E-02(1.071E-02)
03:54:53	6.[illegible]83E-02(-4.617E-02)	7.660E-02(-6.768E-03)	7.436E-02(-4.532E-03)	5.661E-02(1.322E-02)
03:54:54	6.785E-02(-4.815E-02)	7.537E-02(-7.520E-03)	7.267E-02(-4.826E-03)	5.532E-02(1.292E-02)
03:54:55	6.227E-02(-5.272E-02)	7.295E-02(-1.069E-02)	6.940E-02(-7.131E-03)	5.283E-02(9.435E-03)
03:54:56	5.[illegible]41E-02(-5.559E-02)	7.0[illegible]9E-02(-9.637E-03)	6.552E-02(-5.116E-03)	4.988E-02(1.053E-02)
03:54:57	6.352E-02(-5.[illegible]E-02)	7.295E-02(-9.436E-03)	6.940E-02(-5.863E-03)	5.283E-02(1.068E-02)
03:54:58	5.969E-02(-5.631E-02)	7.295E-02(-1.326E-02)	6.940E-02(-9.707E-03)	5.283E-02(6.867E-03)
03:54:59	6.135E-02(-5.465E-02)	7.537E-02(-1.402E-02)	7.267E-02(-1.133E-02)	5.532E-02(6.022E-03)
03:55: 0	5.363E-02(-5.637E-02)	7.355E-02(-1.392E-02)	7.020E-02(-1.057E-02)	5.345E-02(6.184E-03)
03:55: 1	6.163E-02(-5.477E-02)	7.475E-02(-1.312E-02)	7.184E-02(-1.121E-02)	5.469E-02(6.943E-03)
03:55: 2	6.504E-02(-5.096E-02)	7.415E-02(-9.105E-03)	7.102E-02(-5.972E-03)	5.406E-02(1.098E-02)
03:55: 3	6.75[illegible]E-02(-4.850E-02)	7.598E-02(-8.482E-03)	7.351E-02(-6.014E-03)	5.596E-02(1.153E-02)
03:55: 4	6.908E-02(-4.692E-02)	7.537E-02(-6.283E-03)	7.267E-02(-3.589E-03)	5.532E-02(1.376E-02)
03:55: 5	6.984E-02(-4.616E-02)	7.475E-02(-4.915E-03)	7.184E-02(-1.999E-03)	5.469E-02(1.515E-02)
03:55: 6	6.407E-02(-5.193E-02)	7.475E-02(-1.068E-02)	7.184E-02(-7.767E-03)	5.469E-02(9.382E-03)
03:55: 7	7.[illegible]E-02(-4.500E-02)	7.475E-02(-3.755E-03)	7.184E-02(-8.397E-04)	5.469E-02(1.631E-02)
03:55: 8	6.637E-02(-4.957E-02)	7.236E-02(-5.950E-03)	6.861E-02(-2.241E-03)	5.223E-02(1.414E-02)
03:55: 9	7.394E-02(-4.206E-02)	7.5[illegible]9E-02(-4.555E-03)	7.698E-02(-3.042E-03)	5.860E-02(1.533E-02)
03:55:10	7.392E-02(-4.208E-02)	7.355E-02(3.717E-04)	7.020E-02(3.717E-03)	5.345E-02(2.048E-02)
03:55:11	6.868E-02(-4.732E-02)	7.355E-02(-4.865E-03)	7.020E-02(-1.519E-03)	5.345E-02(1.524E-02)
03:55:12	6.61[illegible]E-02(-4.[illegible]E-02)	7.178E-02(-5.597E-03)	6.782E-02(-1.64[illegible]E-03)	5.163E-02(1.455E-02)
03:55:13	7.379E-02(-4.221E-02)	7.537E-02(-1.577E-03)	7.267E-02(1.117E-03)	5.532E-02(1.846E-02)
03:55:14	6.283E-02(-5.311E-02)	7.236E-02(-9.474E-03)	6.861E-02(-5.716E-03)	5.223E-02(1.066E-02)
03:55:15	6.[illegible]92E-02(-4.6[illegible]8E-02)	7.475E-02(-4.832E-03)	7.184E-02(-1.916E-03)	5.469E-02(1.523E-02)
03:55:16	6.696E-02(-4.904E-02)	7.537E-02(-8.406E-03)	7.267E-02(-5.706E-03)	5.532E-02(1.164E-02)
03:55:17	6.171E-02(-5.429E-02)	7.475E-02(-1.305E-02)	7.184E-02(-1.013E-02)	5.469E-02(7.019E-03)
03:55:18	6.270E-02(-5.3[illegible]E-02)	7.475E-02(-1.206E-02)	7.184E-02(-9.144E-03)	5.469E-02(8.015E-03)
03:55:19	6.[illegible]7E-02(-5.593E-02)	7.236E-02(-1.230E-02)	6.861E-02(-8.539E-03)	5.223E-02(7.838E-03)
03:55:20	6.39[illegible]E-02(-5.210E-02)	7.355E-02(-9.552E-03)	7.020E-02(-6.307E-03)	5.345E-02(1.045E-02)
03:55:21	6.[illegible]01E-02(-4.799E-02)	7.355E-02(-5.540E-03)	7.020E-02(-2.194E-03)	5.345E-02(1.456E-02)
03:55:22	5.900E-02(-4.700E-02)	7.005E-02(-1.047E-03)	6.552E-02(3.483E-03)	4.988E-02(1.912E-02)
03:55:23	6.799E-02(-4.691E-02)	7.062E-02(-3.533E-03)	6.628E-02(8.105E-04)	5.046E-02(1.663E-02)
03:55:24	6.788E-02(-4.812E-02)	7.120E-02(-3.319E-03)	6.704E-02(8.330E-04)	5.104E-02(1.684E-02)
03:55:25	6.271E-02(-5.329E-02)	7.005E-02(-7.334E-03)	6.552E-02(-2.803E-03)	4.988E-02(1.284E-02)
03:55:26	5.57[illegible]E-02(-5.[illegible]3[illegible]E-02)	6.948E-02(-1.378E-02)	6.477E-02(-9.069E-03)	4.931E-02(6.392E-03)
03:55:27	5.262E-02(-6.338E-02)	7.005E-02(-[illegible].743E-02)	6.552E-02(-1.290E-02)	4.988E-02(2.738E-03)
03:55:28	5.494E-02(-5.1[illegible]6E-02)	7.0[illegible]5E-02(-1.511E-02)	6.552E-02(-1.058E-02)	4.988E-02(5.050E-03)
03:55:29	5.615E-02(-5.985E-02)	7.236E-02(-1.622E-02)	6.861E-02(-1.246E-02)	5.223E-02(3.917E-03)
03:55:30	5.832E-02(-5.768E-02)	7.120E-02(-1.287E-02)	6.704E-02(-8.721E-03)	5.104E-02(7.285E-03)
03:55:31	5.805E-02(-5.795E-02)	7.005E-02(-1.200E-02)	6.552E-02(-7.472E-03)	4.988E-02(8.167E-03)
03:55:32	5.628E-02(-5.972E-02)	6.836E-02(-1.209E-02)	6.329E-02(-7.018E-03)	4.819E-02(8.091E-03)
03:55:33	5.448E-02(-5.152E-02)	6.892E-02(-1.444E-02)	6.403E-02(-9.548E-03)	4.874E-02(5.736E-03)
03:55:34	5.668E-02(-5.932E-02)	6.892E-02(-1.224E-02)	6.403E-02(-7.346E-03)	4.874E-02(7.938E-03)
03:55:35	5.42[illegible]E-02(-5.33[illegible]E-02)	6.892E-02(-6.715E-03)	6.403E-02(-1.823E-03)	4.874E-02(1.346E-02)
03:55:36	5.926E-02(-5.674E-02)	6.892E-02(-9.654E-03)	6.403E-02(-4.762E-03)	4.874E-02(1.052E-02)
03:55:37	6.[illegible]46E-02(-5.554E-02)	6.836E-02(-7.899E-03)	6.329E-02(-2.832E-03)	4.819E-02(1.223E-02)
03:55:38	5.344E-02(-6.256E-02)	6.726E-02(-1.382E-02)	6.185E-02(-8.416E-03)	4.709E-02(6.349E-03)

	RADAR M (RAD M-MBAR)	M=A*ZR**.5(DELTA M)	M=KC*ZR**.5(DELTA M)	M=KP*ZR**.5(DELTA M)
03155139	4.627E-02(-6.973E-02)	6.726E-02(-2.099E-02)	6.185E-02(-1.559E-02)	4.709E-02(-8.210E-04)
03155140	4.582E-02(-7.018E-02)	5.836E-02(-2.254E-02)	6.329E-02(-1.747E-02)	4.819E-02(-2.366E-03)
03155141	4. 11E-02(-7.589E-02)	6.511E-02(-2.500E-02)	5.907E-02(-1.896E-02)	4.497E-02(-4.061E-03)
03155142	4.32 E-02(-7.279E-02)	6.511E-02(-2.190E-02)	5.907E-02(-1.586E-02)	4.497E-02(-1.760E-03)
03155143	5.043E-02(-5.557E-02)	6.671E-02(-1.628E-02)	6.115E-02(-1.071E-02)	4.655E-02(3.892E-03)
03155144	4. 1 E-02(-6.082E-02)	6.671E-02(-1.954E-02)	6.115E-02(-1.397E-02)	4.655E-02(6.264E-04)
03155145	4.883E-02(-5.717E-02)	6.511E-02(-1.628E-02)	5.907E-02(-1.024E-02)	4.497E-02(3.863E-03)
03155146	4.870E-02(-5.730E-02)	6.564E-02(-1.693E-02)	5.975E-02(-1.105E-02)	4.549E-02(3.214E-03)
03155147	4.446E-02(-7.154E-02)	6.726E-02(-2.280E-02)	6.185E-02(-1.740E-02)	4.709E-02(-2.632E-03)
03155148	4.645E-02(-6.955E-02)	6.617E-02(-1.972E-02)	6.045E-02(-1.400E-02)	4.602E-02(4.333E-04)
03155149	4.355E-02(-7.245E-02)	6.671E-02(-2.316E-02)	6.115E-02(-1.759E-02)	4.655E-02(-2.999E-03)
03155150	3.785E-02(-7.815E-02)	6.511E-02(-2.725E-02)	5.907E-02(-2.121E-02)	4.497E-02(-7.114E-03)
03155151	3.886E-02(-7.714E-02)	6.4 6E-02(-2.520E-02)	5.772E-02(-1.887E-02)	4.395E-02(-5.087E-03)
03155152	3.772E-02(-7.828E-02)	6.406E-02(-2.634E-02)	5.772E-02(-2.000E-02)	4.395E-02(-6.223E-03)
03155153	3.891E-02(-7.709E-02)	6.406E-02(-2.514E-02)	5.772E-02(-1.881E-02)	4.395E-02(-5.031E-03)
03155154	4.536E-02(-7.064E-02)	6.511E-02(-1.974E-02)	5.907E-02(-1.371E-02)	4.497E-02(3.539E-04)
03155155	4.955E-02(-6.645E-02)	6.781E-02(-1.826E-02)	6.257E-02(-1.302E-02)	4.763E-02(1.917E-03)
MEAN	5.435E-02(-5.165E-02)	6.820E-02(-1.385E-02)	6.313E-02(-8.776E-03)	4.806E-02(6.234E-03)
S. D V	9.13 E-03(3.130E-03)	3.450E-03(6.931E-03)	4.551E-03(6.463E-03)	3.464E-03(6.924E-03)

2.2.3 Program GAMMA

GAMMA is a radar and aircraft correlation program designed to help LYC scientists "fine tune" their melting equations by correlating their melted values with radar data.

GAMMA uses the KNOLL1D output tape and raw radar tapes as its data base. Radar Db adjustments are made according to the specifications in section 2.2.1 See below for a list of processing by the program.

PROGRAM TO DETERMINE A GAMMA (1 to d) RELATIONSHIP USING A/C AND RADAR DATA

1. Run 1D program with interpolation for 1 second data using "1 to d" for specified ice type.

1A. Save Z_A, M_A and N/M^3 for each channel

2. Correlate Z_A and Z_R for +/_3 second adjust (Kwajalein data will have offset time - Wallops none)

3. Reject Z_R points according to given minimum and maximum values and corresponding Z_A, M_A and N/M^3 points.

4. Reject Z_A (and M_A, N/M^3) points according to given Z_A minimum and maximum values and corresponding to Z_R points.

5. Save the good Z_A, M_A, N/M^3 and Z_R points.

6. Find mean Z_A, M_A, N/M^3 and Z_R for given averaging period (save)

2.2.3 Program GAMMA (cont'd)

7. Using N/M^3 (averaged, calculate Z and M for rain (physical size).

7A. (save, these parameters now designated Z* and M*)

8. Find λ for each averaging period where

$$\lambda = (Z_R/Z^*)1/6 \qquad \text{(save)}$$

9. Print λ, Z*, M*, k*, Z_A, M_A, k, Z_R for each averaging period.

10. Regression analyses on:

(1) λ vs Z*
(2) λ vs M*
(3) λ vs Z_R
(4) k vs Z_R $\quad (k = M_A/\sqrt{Z_A})$
(5) k* vs Z_R $\quad (k^* = M^*/\sqrt{Z^*})$

11. Using λ vs Z* equation

11A. Find λ for each averaged Z*

11B. Multiply rain mid size channel diameter time λ and then calculate M and Z with N/M**^{3} (designated M** and Z**)

11C. Regression analysis on k** vs Z_R

2.2.3 Program GAMMA (cont'd)

12. Plot scatter diagram and regression lines for each of the 6 analyses. (all to have 3 x 3 cycles)

13. Print

A. power function equation y = ----x^{----}
B. RMS
C. mean y
D. mean x
E. $\Sigma(x-\bar{x})$
F. $\Sigma(x-\bar{x})^2$
G. $\Sigma(x-\bar{x})y$

14. Plot - x axis linear (time), y axes log
λ vs time   y axis .1-10

$Z_R, Z^* + Z_A$ vs time   y axes adjustable

Z_R, Z^{**} vs time   "

$k^* + k$ vs time   "

$M_A + M^{**}$ vs time   "

2.2.3 Program GAMMA (cont'd)

Two assumptions were made about the tapes which helped facilitate its programming. First, we are only interested in the ICE cases, thus in calculating radar Z we do not need to insert code for the rain case calculations. Secondly, KNOLL1D will always be run with the "new output format" and interpolation flags set (1 in columns 55 and 70 of the option card). This generates an output tape with the unmelted center diameters on it although all calculations are done melted. We can do this because GAMMA is being used for the analysis of melting relationships and how they relate to radar data. In other words we are only interested in looking at non-rain data. One point should be made here; Lear data produced by HIAC1D does not have the above option thus an array must be maintained in GAMMA containing the rain case interpolated center diameters.

Program GAMMA accepts a pass from input then accepts or calculates the following parameters for each second of the pass (storing them in arrays for later usage):

Z_A melted aircraft Z (accepted from KNOLL1D output tape)

M_A melted aircraft LWC (accepted from KNOLL1D output tape)

K_A melted aircraft K (accepted from KNOLL1D output tape)

Z_* Rain aircraft Z (calculated from KNOLL1D output tape)

M_* Rain aircraft LWC (calculated from KNOLL1D output tape)

2.2.3 Program GAMMA (cont'd)

K* Rain aircraft K (calculated from KNOLL1D output tape)

New calculated parameter $({}^{Z}R/(4.45Z_*))1/6$

Z** New calculated parameter: Z calculated based upon center diameter of physical size times λ

M** New calculated parameter: same as Z** except LWC

K** $M_{**}/\sqrt{Z**}$

Z_R Radar Z (calculated from radar tape Db values)

A test of Z_A and Z_R is done by shifting +3 to -3 seconds and correcting them. At this point the Z_R data is shifted based upon the best correlation then data at every point of the pass is printed.

A set of LOG scatter plots is now produced with a least square fit line. The associated parameters for each plot are printed immediately following the data above. They are the following plots:

(1) λ vs Z_*
(2) λ vs M_A
(3) λ vs Z_R
(4) K_A vs Z_R
(5) K* vs Z_R
(6) K_{**}vs A_R

2.2.3 Program GAMMA (cont'd)

No further output is given per pass but additional plots are produced. They are

(1) time plot containing three parameters:
Z_R, Z_A and Z_* vs time

(2) λ vs time

(3) three time plots of two parameter each:

Z_R and Z_{**} vs time

K_* and K_A vs time

M_A and M_{**} vs time

Complete operating instructions and sample outputs are found in the following sections.

2.2.3.1 Program GAMMA operating instructions

CONTROL CARDS

```
 DPSI,CM130000,T200,NT1,TP1          ID#       NAME
 ATTACH,LGO,GAMMABIN,ID=GLASS,MR=1.
 REQUEST,TAPE39,*Q.
 DISPOSE,TAPE39,*FM.
 ATTACH,CRT,CRTPLOTS,MR=1.
 LIBRARY,CRT.
*VSN,TAPE1=TAPENO/NT.
 REQUEST,TAPE1,NT,E,NORING.
**VSN,TAPE3=TAPENO.
 REQUEST,TAPE3,MT,NORING.
 LGO.
 7/8/9
```

DATA CARDS

CARD #1

col	5	IAC: 1-C130E,2-LEAR JET,3-C130A
	10	IPROBE: 1-SCATTER,2-CLOUD,3-PRECIP,4-TOTAL PROBE USED
	15	IRAD: 0-SPANDAR,1-MOIST (FIRST),2-MOIST (SECOND) RADAR TYPE FORMAT
	20	LITRAD: 0-SPANDAR,1-ALCOR,2-TRADEX LITERAL USED
	21-30	ROFSET: RADAR OFSET DISTANCE IN METERS (F10.4)
	31-40	DBCOR: GLOBAL D6 CORRECTION (F10.4)
	41-50	DBMIN: MINIMUM DETRACTABLE DB (F10.4)

2.2.3.1 Program GAMMA operating instructions (cont'd)

```
CARDS 2-- (N+1)   (N PASS CARDS)
col 1-2   PASS#(I2)
   5-10   START TIME (HHMMSS)
  13-18   STOP TIME (HHMMSS)
  21-30   A/C ZMIN (F10.4)
  31-40   A/C ZMAX (F10.4)
  41-50   RADAR ZMIN (F10.4)
  51-60   RADAR ZMAX (F10.4)
  71-80   DB PASS CORRECTION (F10.4)
6/7/8/9
```

*KNOLL1D OUTPUT TAPE WITH OPTIONS "INTERP" AND "NEW FORMAT" SET.

**RADAR DATA TAPE.

2.2.3.2 GAMMA sample output

The following pages contain GAMMA sample output.

GAMMA 1X01X01

19MAR80 ABRV-4

PROCESSED ON

THURSDAY

OCTOBER 16 1980

09:39:45

```
PROGRAM GAMMA
VERSION 1.01.01
PROCESSED ON ../16/80
TIME 09.39.45.

LEAR JET

4B?/-4      ON 15 MAR 80
PROGRAM GAMMA
FIRST TEST RES.

TOTAL     PROBE DATA

1 RADAR FORMAT

ALLOR     RADAR USED

3.000 0.0 METERS) - RADAR OFSET DISTANCE

.         GLOBAL DB CORRECTION

-40... .00 MAXIMUM DETECTIBLE DB
```

PASS NO	A/C START	A/C STOP	RADAR START	RADAR STOP	A/C Z MIN	A/C Z MAX	RADAR Z MIN	RADAR Z MAX	DB CORRECTION (+ GLOBAL)	RADAR HEIGHT(M)
1	3?? 68.3	??? 81.8	2?.6?.1	024.8131	-400.0000	400.0000	-400.0000	400.0000	0.0000	12465.35

PASS NO	A/C START STOP		RADAR START STOP		A/C Z MIN MAX		RADAR Z MIN MAX		DB CORRECTION (+ GLOBAL)	RADAR HEIGHT(M)
1	021 61 3	21 8148	021.61 1	0218131	-410 0060	406.0006	-4..0006	400.0000	0.0000	12465.35

CORRELATION COEFFICIENTS OF THE 149 GOOD POINTS FROM 149

SHIFT	-3	-2	-1	0	1	2	3
	25.4	39.1	36.0	33.2	25.4	17.9	17.8

A -2 SEC LAG IS USED

TIME	Z A	M A	K A	Z *	4 *	K *	GAMMA	Z R	REJECTION FLAG
021 61.3	173	.0 26	.176	1.5522	.0576	.0456	.3741	.0191	0
021 6119	.055	.0530	.375	.4253	.0763	.1076	.4790	.0229	0
021.612.	23	.024	.0443	.5239	.0918	.1271	.4615	.0224	0
021 612.	132	.0027	.0469	.3383	.1077	.1728	.4773	.0204	0
021.6122	37	0 26	.6351	1.5113	.1133	.0994	.3932	.0214	0
021.6123	.0 51	.0.3.	.382	.4432	.0861	.1284	.4535	.0174	0
021 5124	32	.0025	.344	.5314	.0781	.1016	.4432	.0200	0
021.6125	.052	.0022	.0275	.4515	.608	0.05	.4696	.0214	0
021 6126	.31	.0019	.344	1336	.0234	.0639	.5571	.0178	0
021.6127	.54	.002-	.0321	1.1515	.0766	.0732	.3982	.0204	0
021 6129	44	.0.17	.0261	.4.38	.0532	.0531	.4694	.0195	0
021 6129	..47	.0026	.0303	.3538	.0667	.1106	.4937	.0234	0
021 613	39	0024	.079	.3395	.0642	1101	.4937	.0219	0
021.6131	.22	.012	.0255	.2416	.0463	.621	.5306	.0240	0
021 6132	3	003	.318	3 2.56	.1195	.060	.3376	.0214	0
021.6133	.0231	..27	.192	1.5459	.0421	.0339	.3894	.0240	0
021 6134	7	.0016	.0425	1.5588	.3338	.0271	.3919	.0251	0
021 6135	.315	.0018	.2.3	2.7715	.0184	.0111	.3547	.0245	0
021 6136	.74	.0 16	.204	1737	.0355	.0851	.5563	.0229	0
021 6137	.2933	.0028	.052	3.1455	.0263	.0157	.3437	.0224	0
021 6138	31	0.23	.0230	1.2514	.0734	.0656	.3958	.0214	0
021.6139	..055	0027	.0360	1.2249	.0723	.0653	.4048	.0240	0
021 614	57	.0 3	.302	2 9433	.1244	.0725	.3593	.0282	0
021 6141	.052	.0029	.372	1.2310	.0302	.0797	.4175	.0302	0
021.6142	23	0.24	.0448	4495	.0715	.1066	.4675	.0209	0
021 6143	..037	.0032	.0341	2.4414	.0867	.0555	.3561	.0229	0
021 6144	73	.0 34	.0398	.2857	0534	.0399	.5200	.0251	0
021 6145	.0.30	.0023	.0424	.3335	.0590	1 61	.5072	.0234	0
021 6145	2 1	.0 29	.231	2.0355	.0901	.0583	.3636	.0245	0
021.6147	.0739	.0031	.01.6	.45..	.0535	.0795	.4783	.0240	0
021.61-3	34	.002	421	.3535	.625	1 4.	.4868	.0219	0
021 6149	.0.42	.0 26	.142	2.9354	.0451	0.64	.3621	.0268	0
021.615	23	0.25	.217	.2155	.0287	.0525	.593.	.0407	0
021.6151	.0315	..023	...76	1.9117	.5.0	.0377	.4150	.0437	0

02#6#53	.371	[illegible]	.1[illegible]3	3.[illegible]	.[illegible]348	.[illegible]20[illegible]	.3680	.0339	0
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02# 6#55	.[illegible]71	[illegible]	.[illegible]	1.6318	.0435	.[illegible]34[illegible]	.3904	.0257	0
02# 6#56	[illegible]	[illegible]13	.[illegible]209	.[illegible]559	.[illegible]	.0447	.6726	.0234	0
02# 6#57	.[illegible]335	[illegible]02[illegible]	.[illegible]376	.4[illegible]8[illegible]	.[illegible]516	.[illegible]08	.4751	.0209	0
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02# 7# 4	53	[illegible]2[illegible]	.[illegible]28[illegible]	.3[illegible]52	.0546	[illegible]932	.4775	.0182	0
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02# 7# 6	[illegible]	.[illegible]21	.[illegible]119	2.9249	.[illegible]468	.0274	.3544	.0182	0
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02#.7#32	23	.[illegible]1[illegible]	.[illegible]226	.[illegible]59	.[illegible]227	.0769	.5695	.0132	0
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02# 7#37	.[illegible]9	[illegible]8	.[illegible]	.1552	.0359	.[illegible]918	.5261	.0145	0
02# 7#38	.[illegible]3[illegible]	0023	.[illegible]423	.2[illegible]15	.[illegible]5[illegible]	.1108	.4821	.0129	0
02#[illegible]7#39	.[illegible]25	.[illegible]018	.[illegible]357	[illegible].3313	.[illegible]883	.0774	.3655	.0136	0
02#.7#4	.[illegible]3	.[illegible]16	.0325	.2737	.[illegible]455	.[illegible]569	.4746	.0138	0
02#.7#41	.[illegible]7	.[illegible]019	.[illegible]357	.3256	.[illegible]599	.1045	.4597	.0138	0
02#.7#42	.[illegible]2	.[illegible]01[illegible]	.[illegible]334	.[illegible]372	.[illegible]29[illegible]	.[illegible]929	.5697	.0148	0
02#.7#43	.[illegible]9	.[illegible]	.262	.1[illegible]	.0387	.[illegible]9[illegible]	.5180	.0129	0
02#.7#44	15	.[illegible]	.0324	.0757	.[illegible]241	.0[illegible]62	.5972	.0155	0
02# 7#45	.[illegible]21	.[illegible]	.314	.[illegible]976	.[illegible]294	.0992	.5884	.0162	0
02#.7#46	.[illegible]	.[illegible]1[illegible]	.362	2257	.0[illegible]	[illegible]943	.4951	.0148	0
02#.7#47	.[illegible]23	0[illegible]	.319	.0354	.[illegible]261	.0906	.5727	.0151	0
02#.7#48	34	[illegible]026	.[illegible]441	.4501	.[illegible]79[illegible]	.1182	.4396	.0145	0
02# 7#49	.[illegible]3	.[illegible]	.[illegible]389	.1[illegible]	.[illegible]	.[illegible]259	.5321	.0151	0
02#.7#5	.[illegible]53	.[illegible]72[illegible]	.[illegible]97	3.2[illegible]6	.11[illegible]	[illegible]634	.3103	.0129	0
02# 7#5	.[illegible]18	.[illegible]	.[illegible]53	2[illegible]1[illegible]	.[illegible]394	.0[illegible]02	.4953	.0158	0
02#.7#52	35	[illegible]027	.[illegible]2	.2786	.0[illegible]81	.1[illegible]7[illegible]	.5135	.0170	0
02#.7#53	.[illegible]25	[illegible]9	.[illegible]379	.1549	.[illegible]5[illegible]	.1232	.5297	.0162	0
02#.7#54	.[illegible]3	.[illegible]2[illegible]	.[illegible]391	.3[illegible]55	.[illegible]595	.1[illegible]6[illegible]	.4628	.0[illegible]38	0
02# 7#55	.[illegible]8	.[illegible]6	.39[illegible]	.0570	.[illegible]216	.[illegible]531	.5692	.0126	0
02# 7#5[illegible]	.[illegible]2[illegible]	.[illegible]2[illegible]	.5[illegible]2	[illegible]27[illegible]	.[illegible]7[illegible]7	[illegible]36	.458[illegible]	.0[illegible]5	0
02#.7#57	.[illegible]7	.[illegible]	.[illegible]67	.[illegible]1[illegible]1	.[illegible]368	1[illegible]7	.5636	.0166	0

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
021 7159	. 30	.017	. 310	.3930	. 217	.0727	.5870	.0162	0
021081	. 34	.0.26	.0443	1.1786	.130	.1041	.3730	.0141	0
0210811	.3.5	.0023	. 463	.1333	.0558	.1270	.5061	.0145	0
021.01 2	33	0126	. 427	.2578	.0674	.1303	.4849	.0155	0
021.81 3	.1025	.0027	.0345	.0593	.0203	.0333	.6306	.0166	0
021 81 4	32	0025	. 433	.2.91	.1564	.1234	.5072	.0158	0
021 8105	.3 40	0028	.0446	.1538	.1547	.1353	.5364	.0162	0
021 01 6	27	.0 19	.0364	.0382	.0231	.0779	.5970	.0178	0
021 81 7	.0035	.0026	. 347	.2825	.0475	.0893	.4699	.0174	0
021 81 8	47	.0 26	.04.4	.3739	.0757	.1244	.4663	.0174	0
021 81.9	.. 31	.0024	.0429	.1136	.. 316	.0936	.5679	.0178	0
021 011	44	. 34	. 513	1.0329	.0846	.0813	.4038	.0209	0
0210811	.0052	.0028	.0061	.6122	.0951	.1.13	.4146	.0200	0
0210812	4.	0.25	.0391	.8812	.0541	.0576	.4131	.0195	0
021 8113	.014	.025	. 440	.1739	.1518	.1236	.5425	.0208	0
021 0114	3.	.0014	.0258	.1938	.0202	.0574	.5908	.0170	0
021 81 5	.0026	.0018	.0356	.151.	.0469	.1019	.5464	.0195	0
021 0116	37	0.34	. 446	.393.	.0742	.1181	.4618	.0178	0
021 81 7	.. 51	.0022	.0452	.6103	.1105	.1415	.4409	.0200	0
0210113	55	0 45	.0001	.4459	.0956	.1423	.4628	.0195	0
021 81.9	.0054	.0033	. 412	.3539	.0630	.1050	.4760	.0186	0
0210012	59	.0.39	.0391	.1826	.0537	.1256	.5228	.0166	0
0210121	.0.23	.0049	. 442	5.1339	.1044	.0013	.3056	.0186	0
0210122	55	0.43	.0328	.3554	.0661	.1094	.4952	.0240	0
021 8123	.0035	.0004	.0473	.5524	.1042	.1402	.4587	.0229	0
021 012.	53	.0082	. 407	.4334	.0849	.1201	.4665	.0229	0
021 81.5	.0049	.0028	.0435	.3917	.0665	.1154	.5091	.0257	0
0210126	42	0 32	. 475	.2594	.0722	.1417	.5243	.0240	0
0210127	.033	.0037	. 515	.4017	.0844	.1315	.5025	.0295	0
021 .123	. 3	0045	.0447	.1902	.0446	.1023	.5694	.0288	0
0210129	. 32	.0055	.0578	.6030	.1130	.1419	.4867	.0380	0
021. 13	32	0.50	.0549	.2122	.3704	.1529	.5854	.0380	0
021 813.	.3150	0 78	.3636	1.8161	.2144	.1591	.4237	.0468	0
0210132	155	0087	.0573	2.0309	.1737	.1.1.	.3761	.0372	0
021.0133	. 217	0111	.0753	3.5584	.2835	.1501	.3533	.0309	0
021 0134	152	0047	.1794	2.0363	.2814	.1974	.3764	.0257	0
021.0135	.052	0062	.0052	.6027	.1160	.1372	.4473	.0229	0
0210135	. 73	0057	.0664	.6932	.1365	.1652	.4327	.0260	0
021 8137	.0059	.0050	.0007	2.7368	.1504	.0599	.3501	.0229	0
021 0133	43	0.3.	.0093	.552.	.1029	.1385	.4432	.0186	0
0210139	.0054	.0038	. 521	.4534	.0752	.1109	.4576	.0186	0
021 014	36	0.34	. 357	.2792	.0555	.1.50	.5062	.0209	0
021.0141	.0048	.0037	.1535	.3526	.0701	.1165	.4736	.0182	0
021 0142	53	.0036	.0006	.1146	.0412	.1216	.5805	.0195	0
0210143	.0035	.0043	. 722	.1714	.0483	.1166	.5365	.0182	0
0210144	23	0 16	.0326	.130.	.0285	.0301	.5825	.0174	0
0210145	. 31	.0023	. 414	.2539	.0462	.0305	.50.6	.0182	0
021 0146	43	.0 37	.0528	.1372	.0538	.1611	.5262	.0186	0
	. 114	.0027	. 371	.7534	.0637	.0948	.4802	.0200	

0 - ACCEPTED
1 - A/C REJECTION
2 - NO RADAR
3 - A/C REJECTION AND NO RADAR
4 - RADAR REJECTION
5 - RADAR AND A/C REJECTION

****

GAMMA = (41181A/C Z-RAIN (-.1.55)

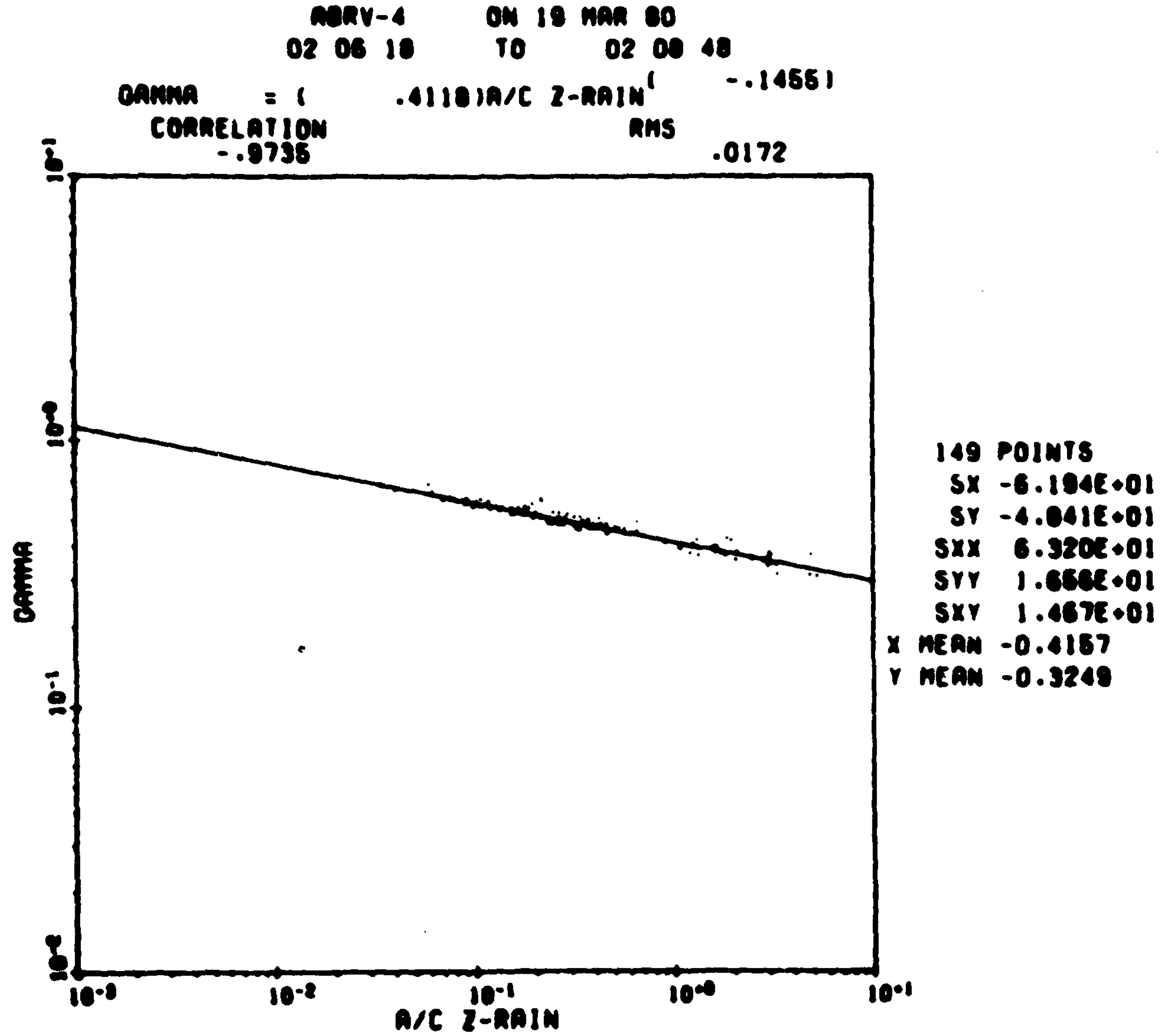
RMS .72
CORRELATION COEFFICIENT = .35
1.9 POINTS USED

```
MEAN          32 9                  -..1.7
SX          -.3 4 55             -61 9300
SXX          15 553               63.1367
SXY                   14.6719

*************************************************************************************

                                  (     -.1698)
  GAMMA     = (      .1597)  LWC-ICE

RMS            657.
CORRELATION CO FFIC.INT     -.4371
         1.9 POINTS USED
          GAMMA                  LWC-ICE
MEAN        - 32..                -2.6258
SX         -.8.4556              -393...58
SXX         16 553.              1131..2.4
SXY                  126.6080

*************************************************************************************

                                  (     -..965)
  GAMMA     = (      .21.7)  RADAR Z

RMS            . 7.1
CORRELATION COEFFICIENT     -.3.72
         1.9 POINTS USED
          GAMMA                  RADAR Z
MEAN        - 32-9                -1 .156
SX         -45 4.55              -255.77.0
SXX         15 553.              441.2335
SXY                   82 6651

*************************************************************************************

                                  (     -.2920)
  K-ICE     = (      ..J0)  RADAR Z

RMS            .105
CORRELATION COEFFICIENT     -.1697
         1.9 POINTS USED
          K-ICE                  RADAR Z
MEAN        -1 47.3               -1.7156
SX         -219 .5..             -255 .7.0
SXX         32..7..               .4..23 5
SXY                  376 0665

*************************************************************************************

                                  (     -.3690)
  K-RAIN    = (      .202,  RADAR Z

RMS            . 96
CORRELATION CO FFIC INT     - 2221
         149 POINTS USED
          K-RAIN                 RADAR Z
MEAN        -1  . 2               -1.7155
SX         -157 37.7             -.55.77.0
SXX         173.51.5              .4. 2305
SXY                  27 .37.7

*************************************************************************************

                                  (  .   - 3090)
  K-GAMMA   = (        2 2)  RADAR Z
```

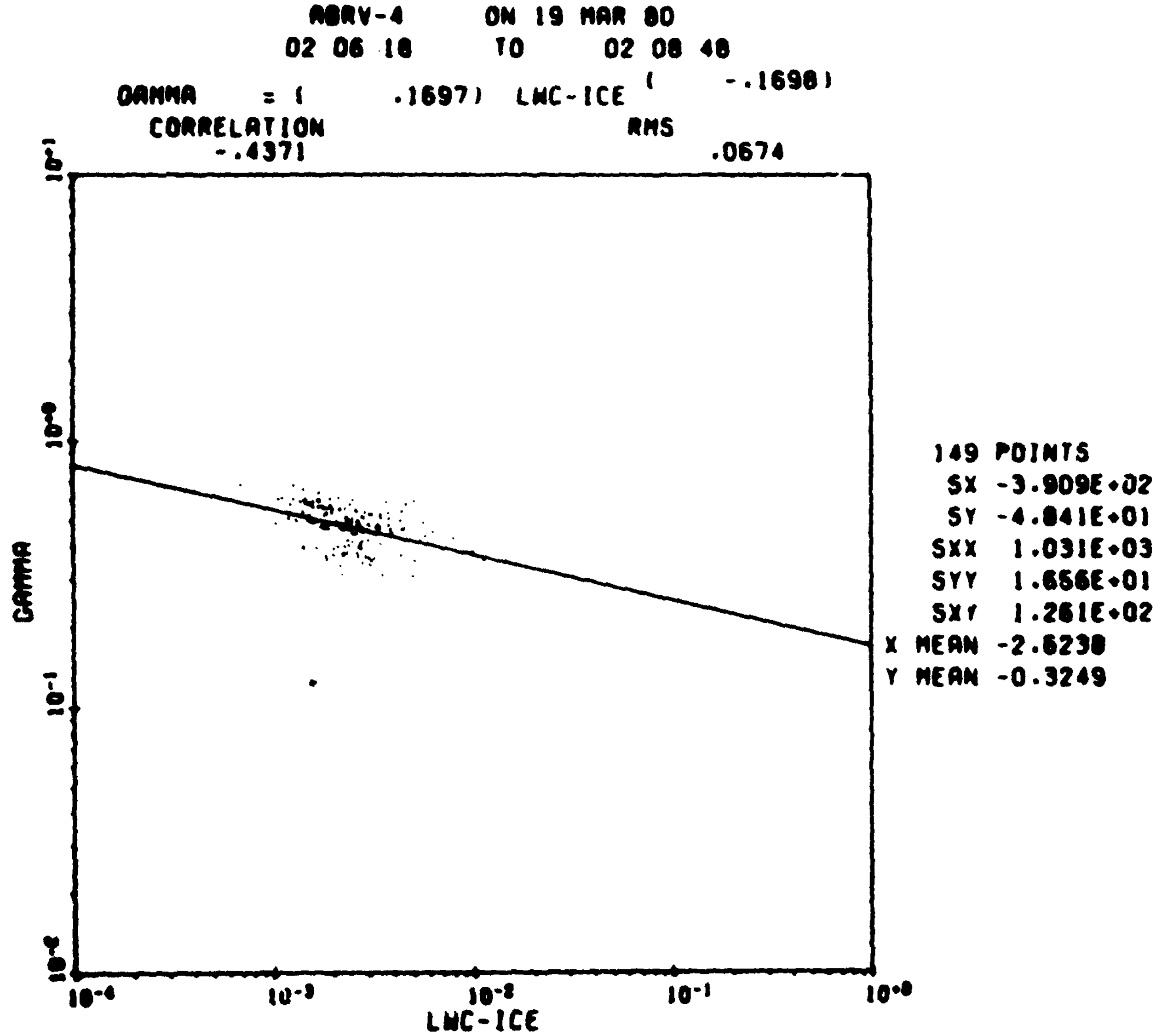
```
RMS            1363
CORRELATION COEFFICIENT     -.2421
          49 POINTS USED
          K-GAMMA                RADAR Z
MEAN        -.[illegible]63.2         -1.7166
SX         -157 97.7            -255.77
SXX         173 5135             44.2305
SXY                  270 3707
```

****

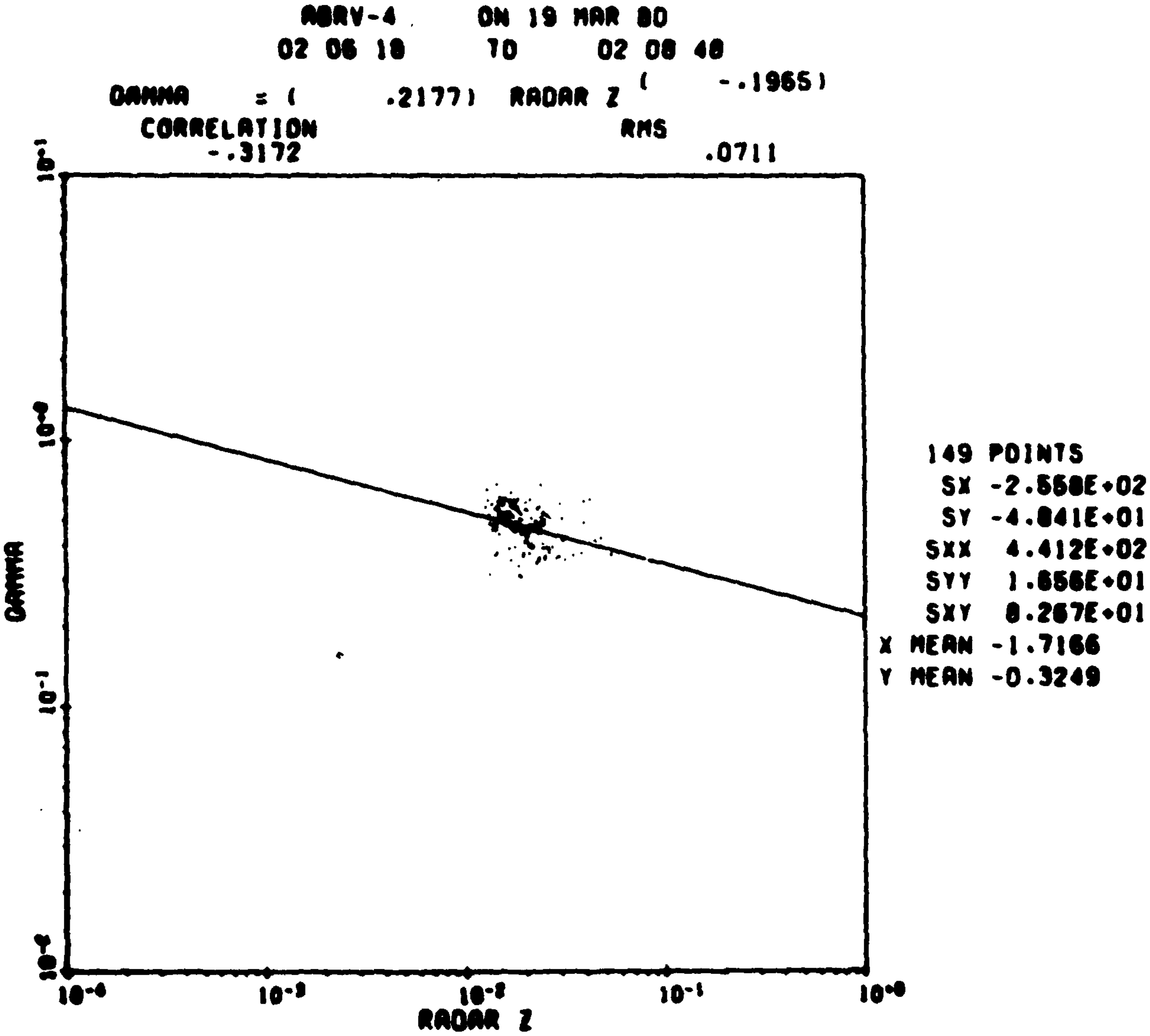
2.2.3.3 GAMMA sample plots



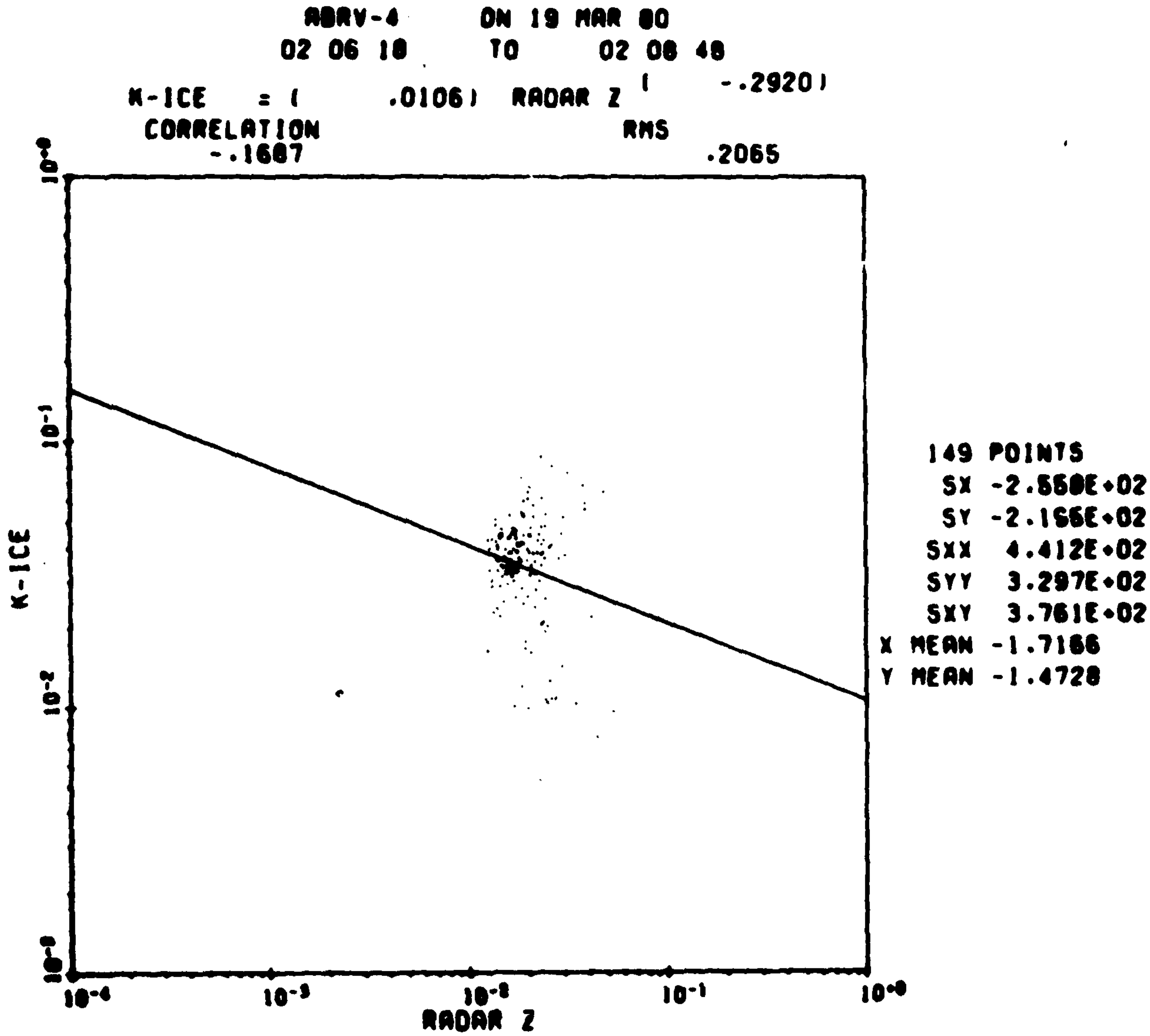
2.2.3.3 GAMMA sample plots (cont'd)



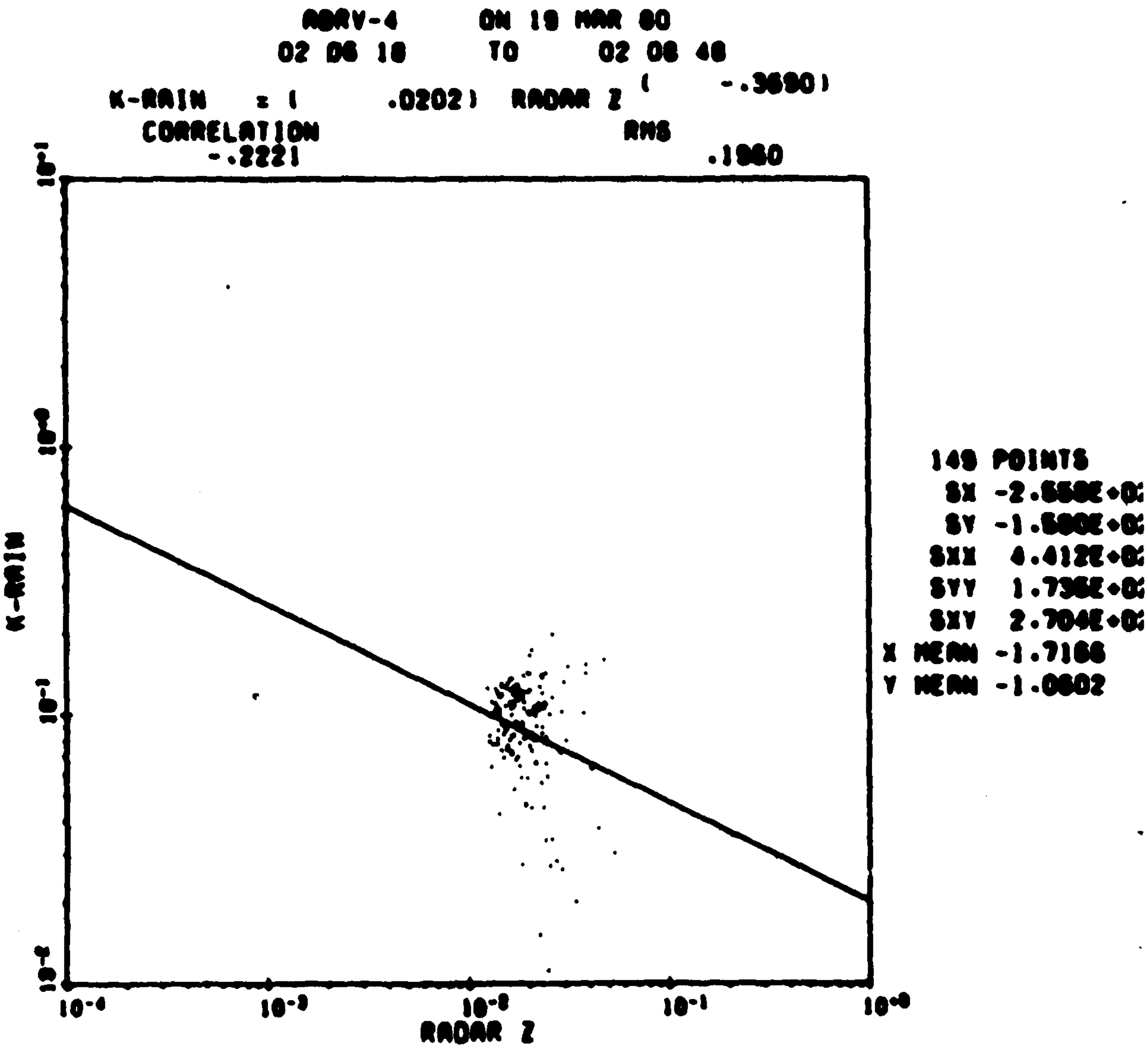
2.2.3.3 GAMMA sample plots (cont'd)



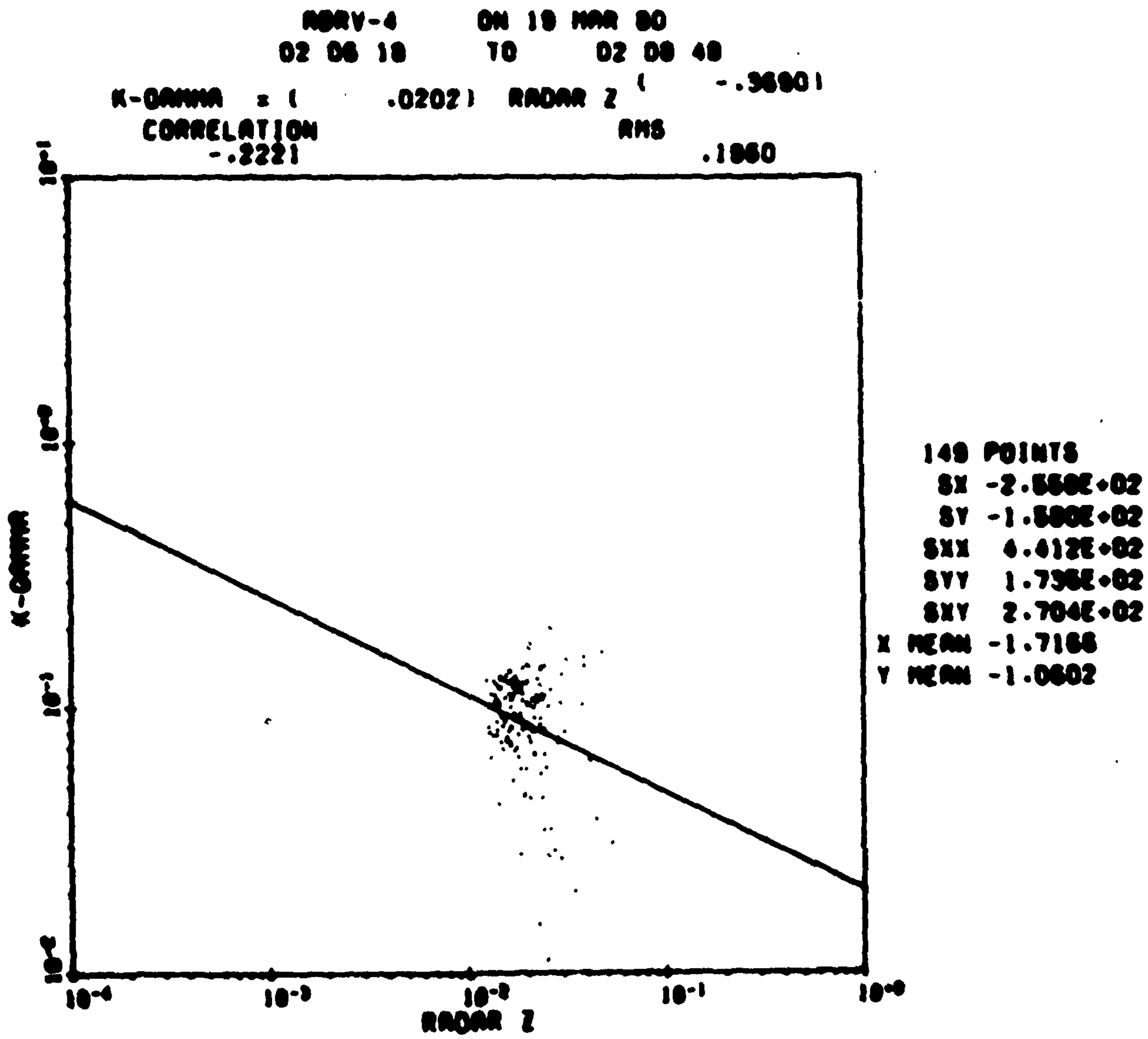
2.2.3.3 GAMMA sample plots (cont'd)



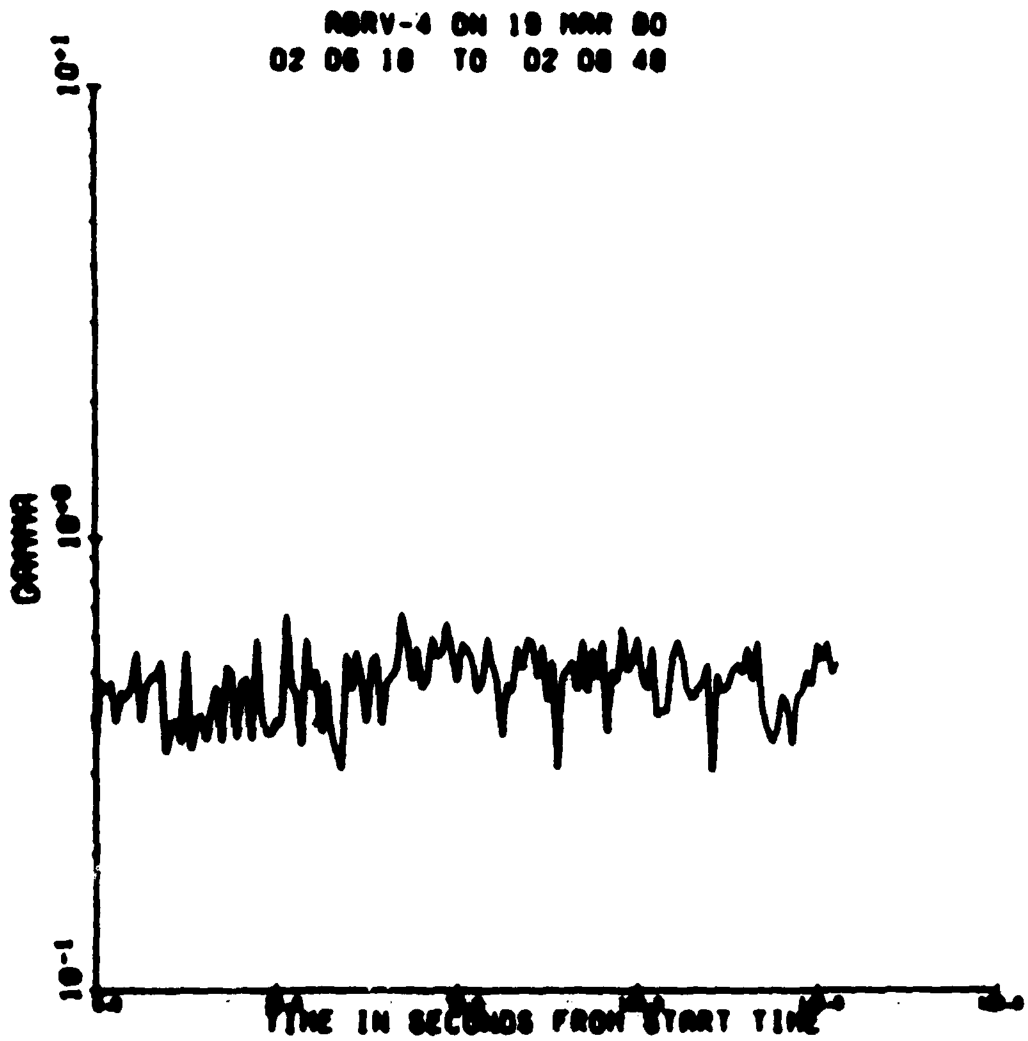
2.2.3.3 GAMMA sample plots (cont'd)



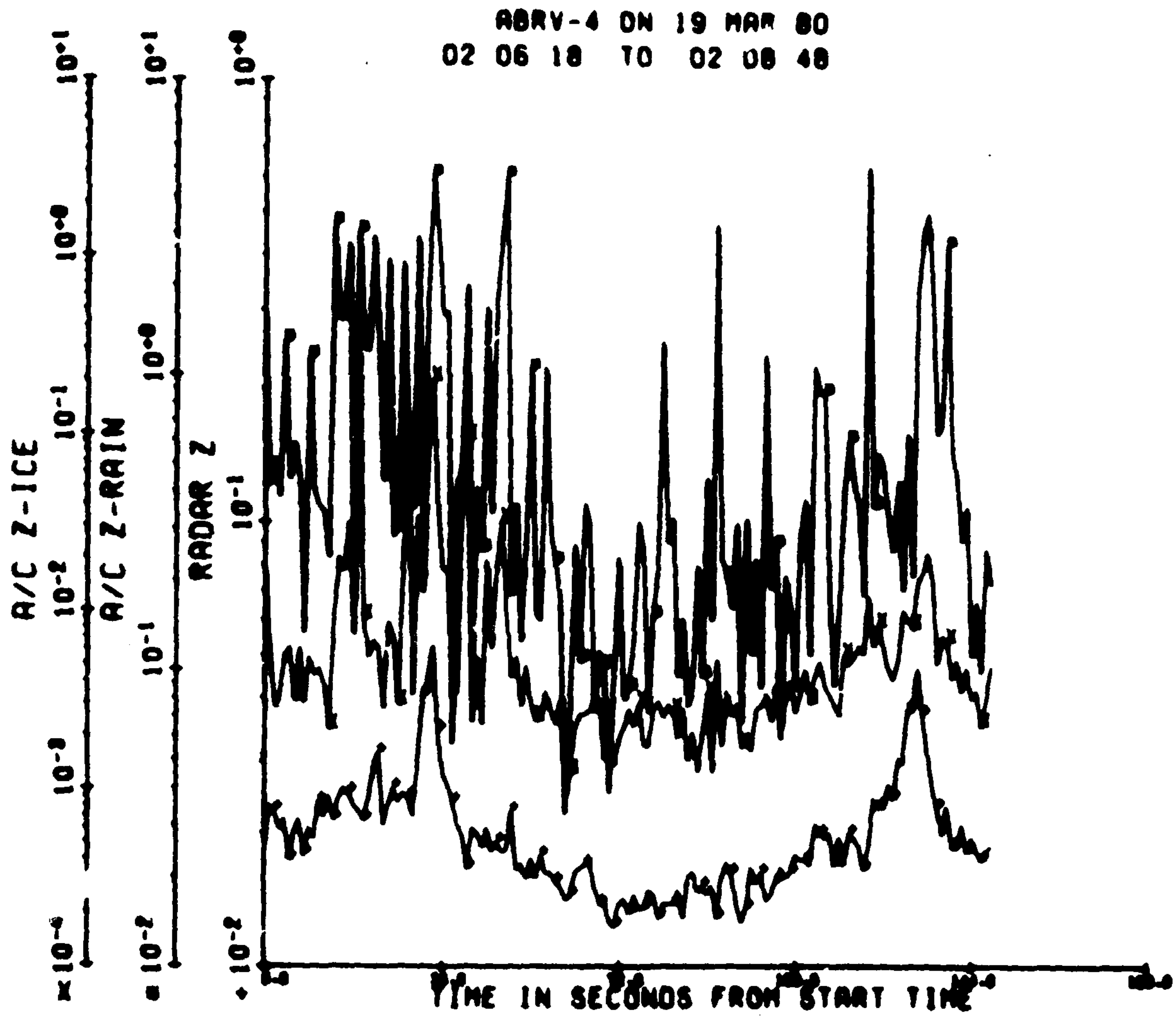
2.2.3.3 GAMMA sample plots (cont'd)



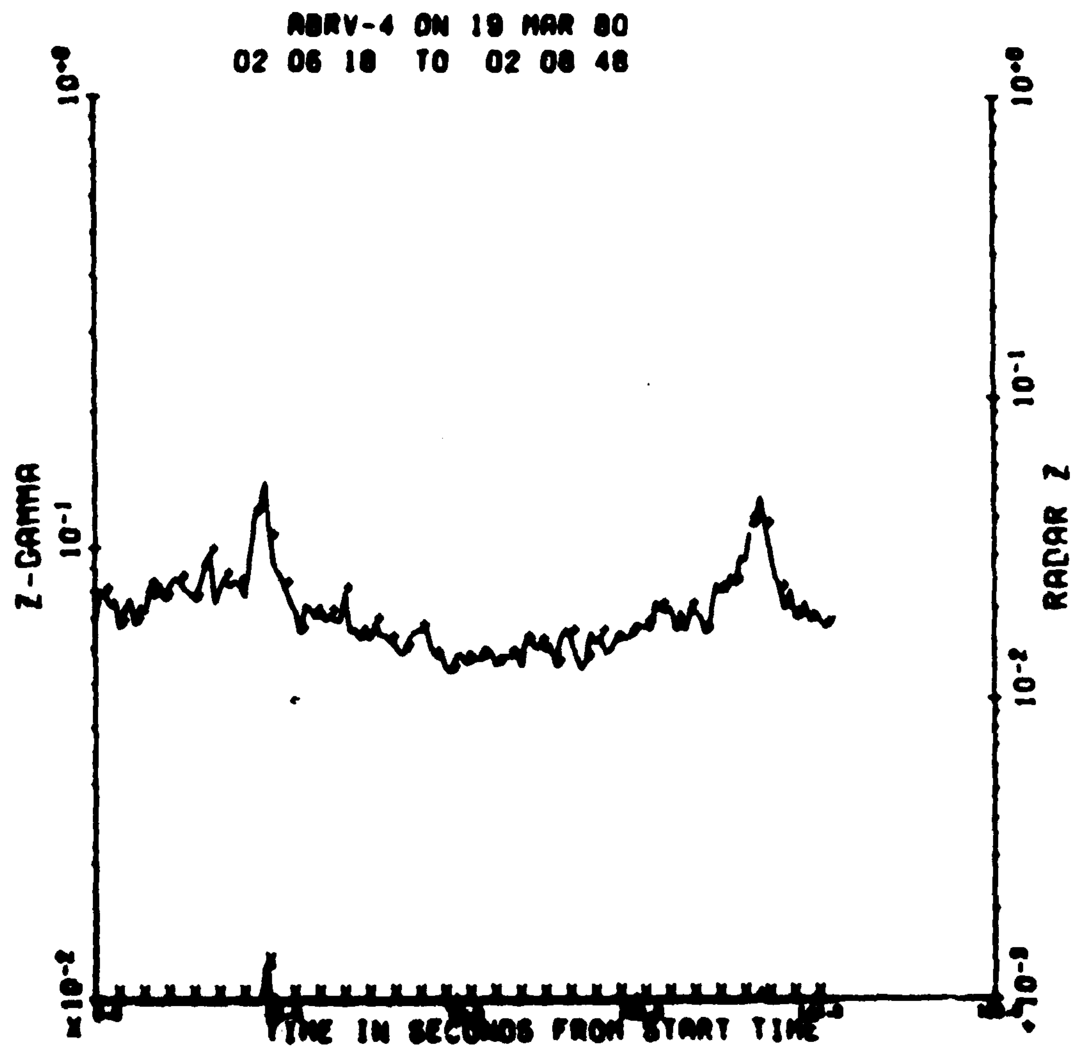
2.2.3.3 GAMMA sample plots (cont'd)



2.2.3.3 GAMMA sample plots (cont'd)



2.2.3.3 GAMMA sample plots (cont'd)



2.2.4 Program SPANDAR

Program SPANDAR takes the IBM 360 generated radar correlation tape and reformats it into a CDC 6600 SCOPE-NOS/BE compatible tape. SPANDAR can only be run under the CDC 6600 batch processor via card input.

Input is the radar data tape (appendix 9) containing DBZ values generated during an aircraft sampling pass in Wallops Island vicinity. It is processed by the Applied Physics Lab at John Hopkins University before being sent to AFGL/LYC.

There are five different output options available from SPANDAR:

1. lineprinter plot of Z (TAPE2)
2. CDC 6600 data tape (TAPE3)
3. data summary printout (TAPE7)
4. tape listing - formatted (TAPE8)
5. punched cards (TAPE4)

TAPE3 can be used as input to program RAPP for correlation with aircraft data; see appendix 10 for its format. SPANDAR operating instructions follow in the next sections.

2.2.4.1 Program SPANDAR operating instructions

Control Cards

```
JOBNM,CM65000,T50,TP2.*                   PROB NO.      NAME
REQUEST,TAPE1,L,MT,VSN=TAPENO.   (7 TRACK - NO RING)
REQUEST,TAPE3,MT,RING,VSN=TAPENO.*   (7 TRACK - RING)
ATTACH,LGO,SPANDARBIN,ID=GLASS,MR=1.
FILE(TAPE1,RT=U,BT=K,MRL=5339,MBL=5339,RB=1,BFS=536)
MAP,OFF
LDSET,FILES=TAPE1,PRESET=ZERO.
LGO.
REWIND,TAPE8.
                     FOR TAPE LISTING
COPY,TAPE8.
REWIND,TAPE2.
                     FOR LINE PRINTER PLOT
COPY,TAPE2.
6/7/8/9
```

* FOR NO OUTPUT TAPE REMOVE REQUEST,TAPE3,... CARD AND CHANGE TP2 TO TP1

Data Cards

NONE REQUIRED

2.2.4.2 SPANDAR sample output

Output Description

The standard SPANDAR output format is a summary of all the data on the converted tape. The page headings specify which aircraft the radar was tracking and each block underneath specifies one correlated radar-aircraft track. For instance, in figure 2.17the C130 aircraft was tracked on 22 MAR 77 from 14:15:54 until 14:16:33 at an average height of 1400 feet. This track is referenced as pass 3.

Optional TAPE8 (figure 2.18) output is a complete listing of every item on the data tape. On the top of each page is an expansion of the pass summary block listing aircraft and times. The rest of the page is devoted to the tabular values given on the radar tape:

HH:MM:SS.F	time sample was collected (once a second)
Z(DBZ)	radar reflectivity
EL(DEG)	radar elevation in degrees
AZ(DEG)	azimuth in degrees
RSLRA(NM)	slant range to the aircraft in nautical miles
GRRA(NM)	ground distance to the aircraft in nautical miles
GR RA(KM)	altitude in kilometer

Optional output TAPE2 is a line printer plot figure 2.19 of radar reflectivity (Z) vs. time. The range of Z is -25.0 DBZ to +25.0 DBZ in increments of .5 DBZ. The program divides the data into one minute group with a series of bars, but does not cause a break in the graph. The time, the slant range, and the value of Z are printed to the side of each point plotted.

```
                    C130               LEAR
                    ******             ******

   1     DATE   22 MAR 77
         PASS     3
         FROM   14:15:54.0
           TO   14:16:33.0
           HT    1400.0 FT

   2     DATE   22 MAR 77
         PASS     5
         FROM   14:18:39.0
           TO   14:19:16.0
           HT    1200.0 FT

   3     DATE   22 MAR 77
         PASS     5
         FROM   14:34:14.0
           TO   14:34:28.0
           HT    4800.0 FT

   4     DATE   22 MAR 77
         PASS     5
         FROM   14:34:34.0
           TO   14:35:19.0
           HT    4900.0 FT

   5     DATE   22 MAR 77
         PASS     5
         FROM   14:35:24.0
           TO   14:35:37.0
           HT    4900.0 FT

   6     DATE   22 MAR 77
         PASS     5
         FROM   14:35:42.0
           TO   14:37:58.0
           HT    4900.0 FT

   7     DATE   22 MAR 77
         PASS     7
         FROM   14:57: 5.0
           TO   14:58: 2.0
           HT    1300.0 FT

   8     DATE   22 MAR 77
         PASS     7
         FROM   14:58: 7.0
           TO   14:59:17.0
           HT    1300.0 FT
```

520

Figure 2.17: SPANDAR output summary

22 MAR 77 C130 PASS 3 1400.00 FT SCAN 5
40 SECONDS FROM 14:15:38.4 TO 14:16:13.4

HR:MN:SC.F	Z(DBZ)	EL (DEG)	AZ (DEG)	RSLRA (NM)	GR RA (NM)	GR RA (KM)	ALT (FT)	ALT (KM)
14:15:54.0	17.3	1.1	100.9	11.0	11.0	20.3	1362.6	.4
14:15:55.0	15.9	1.1	100.9	10.9	10.9	20.2	1352.0	.4
14:15:56.0	17.4	1.1	100.9	10.8	10.8	20.0	1341.4	.4
14:15:57.0	17.7	1.1	100.9	10.8	10.8	20.0	1341.4	.4
14:15:58.0	18.4	1.2	100.9	10.8	10.8	19.9	1481.3	.5
14:15:59.0	19.1	1.2	101.0	10.8	10.8	19.9	1481.3	.5
14:16: 0.0	18.0	1.2	101.0	10.7	10.7	19.7	1469.6	.4
14:16: 1.0	17.7	1.2	101.0	10.6	10.6	19.6	1457.9	.4
14:16: 2.0	17.9	1.2	101.1	10.6	10.6	19.6	1457.9	.4
14:16: 3.0	17.4	1.2	101.1	10.5	10.5	19.4	1446.2	.4
14:16: 4.0	16.2	1.2	101.2	10.4	10.4	19.3	1434.5	.4
14:16: 5.0	16.5	1.2	101.2	10.4	10.4	19.3	1434.5	.4
14:16: 6.0	16.5	1.2	101.3	10.4	10.4	19.1	1422.9	.4
14:16: 7.0	15.3	1.2	101.4	10.4	10.4	19.1	1422.9	.4
14:16: 8.0	15.4	1.2	101.4	10.3	10.3	19.0	1411.2	.4
14:16: 9.0	15.5	1.2	101.4	10.2	10.2	18.9	1399.5	.4
14:16:10.0	15.2	1.2	101.5	10.2	10.2	18.9	1399.5	.4
14:16:11.0	15.0	1.2	101.5	10.1	10.1	18.7	1387.9	.4
14:16:12.0	15.2	1.2	101.5	10.0	10.0	18.6	1376.2	.4
14:16:13.0	15.3	1.2	101.6	10.0	10.0	18.6	1376.2	.4
14:16:14.0	15.2	1.2	101.6	9.9	9.9	18.4	1364.6	.4
14:16:15.0	15.1	1.3	101.7	9.9	9.9	18.4	1457.4	.4
14:16:16.0	14.4	1.3	101.7	9.9	9.9	18.3	1445.0	.4
14:16:17.0	15.7	1.3	101.8	9.8	9.8	18.1	1432.6	.4
14:16:18.0	15.0	1.3	101.8	9.8	9.8	18.1	1432.6	.4
14:16:19.0	15.1	1.3	101.9	9.7	9.7	18.0	1420.3	.4
14:16:20.0	14.8	1.3	102.0	9.7	9.7	18.0	1420.3	.4
14:16:21.0	15.5	1.2	102.0	9.7	9.7	18.0	1323.8	.4
14:16:22.0	15.5	1.2	102.1	9.6	9.6	17.8	1318.2	.4
14:16:23.0	15.0	1.2	102.1	9.6	9.6	17.8	1318.2	.4
14:16:24.0	14.8	1.2	102.1	9.5	9.5	17.7	1306.6	.4
14:16:25.0	14.2	1.2	102.2	9.5	9.5	17.5	1295.0	.4
14:16:26.0	14.1	1.3	102.2	9.5	9.5	17.5	1383.2	.4
14:16:27.0	13.7	1.3	102.4	9.4	9.4	17.4	1370.9	.4
14:16:28.0	13.5	1.3	102.4	9.3	9.3	17.2	1358.6	.4
14:16:29.0	13.7	1.3	102.4	9.3	9.3	17.2	1358.6	.4
14:16:30.0	13.3	1.3	102.4	9.2	9.2	17.1	1346.3	.4
14:16:31.0	13.4	1.3	102.4	9.2	9.2	17.1	1346.3	.4
14:16:32.0	12.7	1.3	102.5	9.1	9.1	16.9	1334.0	.4
14:16:33.0	12.8	1.3	102.4	9.1	9.1	16.8	1321.7	.4

Figure 2.18: SPANDAR (TAPE8) output

RADAR Z(DBZ) 27 FEB 77 C130 PASS 2

TIME	RSLR(FT)	Z(DBZ)
22:37:32	127373	15.5
22:37:33	127373	14.8
22:37:34	127865	15.2
22:37:35	128357	14.0
22:37:36	128357	14.4
22:37:37	128849	14.0
22:37:38	129340	14.4
22:37:39	129340	14.4
22:37:40	129832	14.9
22:37:41	129832	15.5
22:37:42	130324	15.8
22:37:43	130815	16.7
22:37:44	130815	17.2
22:37:45	131307	17.1
22:37:46	131799	17.6
22:37:47	131799	17.2
22:37:48	131799	17.7
22:37:49	131799	17.8
22:37:50	132291	17.5
22:37:51	132783	17.3
22:37:52	132783	18.0
22:37:53	133275	18.1
22:37:54	133766	18.8
22:37:55	133766	18.6
22:37:56	134258	18.7
22:37:57	134258	17.6
22:37:58	134750	17.1
22:37:59	135242	15.4
22:38:00	135242	15.3
22:38:01	135734	15.3
22:38:02	133275	16.8

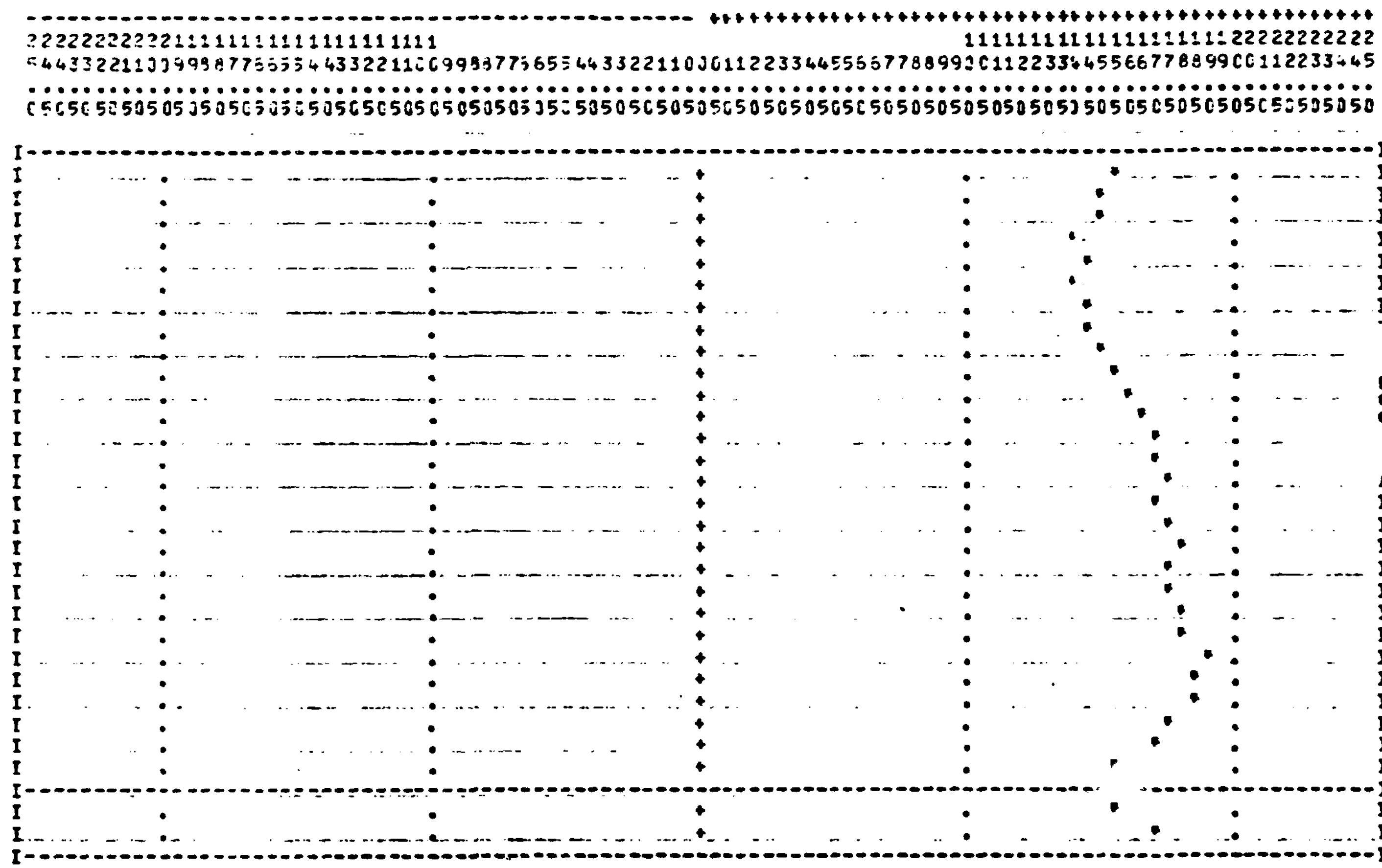


Figure 2.19: SPANDAR (TAPE2) output

2.2.5 Program ZDMP

Program ZDMP was written to give a quick dump of radar Z values. The program was designed such that it could dump either moist radar data or the SPANDAR created output tape.

ZDMP strips off the Z values and outputs it in 1,5,and 10 second averages as well as pass averages for a given interval. Operating instructions for ZDMP appear below.

CONTROL CARDS

```
DPSI,CM40000,T150,TP1.        ACT           NAME
ATTACH,LGO,ZDMPBIN,ID=GLASS,MR=1.
VSN,TAPE3=TAPENO.
REQUEST,TAPE3,NORING,MT.
LGO.
```

DATA CARDS

CARD 1

COLUMN	
1-20	ID INFO (2A10 FORMAT)
21-25	NSKIP(15): NUMBER OF HEADER RECORDS TO SKIP BEFORE PROCESSING THE DATA
26-30	NRAD(15): 0 - SPANDAR RADAR USED 1 - MOIST RADAR (FIRST RADAR ON TAPE) 2 - MOIST RADAR (SECOND RADAR ON TAPE)
31-35	NTYPE(15) 0 - SPANDAR LITERAL USED

2.2.5 Program ZDMP operating instructions (cont'd)

	1 - ALCOR LITERAL USED
	2 - TRADEX LITERAL USED
41-50	DBCOR(F10.4) DBZ CORRECTION

CARDS (2-(N+1) - N PASSES

1-2	NPASS(I2) - PASS NUMBER
4-16	START AND STOP TIMES (HHMMSS.HHMMSS)
17-20	IRACOR(I4) = WHEN NOT EQUAL TO ZERO Db CORRECTION IS SET TO 6.5 (WALLOPS ICE DATA)

2.3 PMS-2D Data Processing

The PMS-2D hardware configuration is described below.

MC-130

Two PMS-2D particle display systems with two size ranges (25-800μ and 200-6400μ) tied to dual Pertec (model F5640-9) digital recorders.

LEAR

Two PMS-2D particle display systems with two size ranges (40-1280μ and 160-5120μ) tied to a Pertec (model T7640-9) digital recorders.

The 2D Knollenberg has some important advantages over the earlier 1D model. Firstly, there are 32 sensors each exactly 25μ in diameter. The second dimension is achieved by taking readings over time so that a two dimensional picture of the shadow is made. The sampling rate is adjusted to the speed of the aircraft so that a reading would be taken every 25μ of length. That is, if the aircraft flies at 100 meters/sec, the sampling rate would have to be 4 megahertz. This exact ratio cannot be maintained perfectly, so the results are modified slightly in the computer according to the true airspeed of the aircraft. Like the 1D device, the output is turned on when a sensor is shut off, and continues until all sensors are back on, but this device will output the status of each of the 32 sensors every four-millionth of a second until all the sensors are back on. Thus the 2D device gives a picture of the particle(s) as subsequent readouts are placed together, and will not give incorrect results when two

2.3 PMS-2D Data Processing (cont'd)

particles are seen simultaneously.

An additional advantage of the 2D system is the end rejection feature. If a particle occludes either ending diode, it is still recorded on magnetic tape. On the 1D system these particles are not counted and the data is lost.

The reason for this rejection is the philosophy of the 1D system; if the ending diode is occluded, there is no way to estimate the true particle length and it was felt, at the engineering design level, that it would be better to eliminate the particle rather than counting it as one with a lesser diameter. With that in mind, the end diode rejection feature was incorporated into the 1D system. An area of concern, however, is the number of particles being rejected; with the present 1D system there is no way to determine this. It may be of considerable consequence because the larger particles have the greatest probability of being rejected, and it is precisely these particles which will contribute heavily to the liquid water content and radar reflectivity.

DPSI designed and developed a new set of programs to analyze the data obtained from the 2D PMS Knollenberg devices. The details of this design follow in these sections. (see figure 2.20)

The 2D particle display system is a valuable source of data to LYC. Data is collected from two independent systems (one each on the MC-130 and Learjet) and recorded on magnetic tape using a nine-track Pertec recorder. Only the C130 tapes

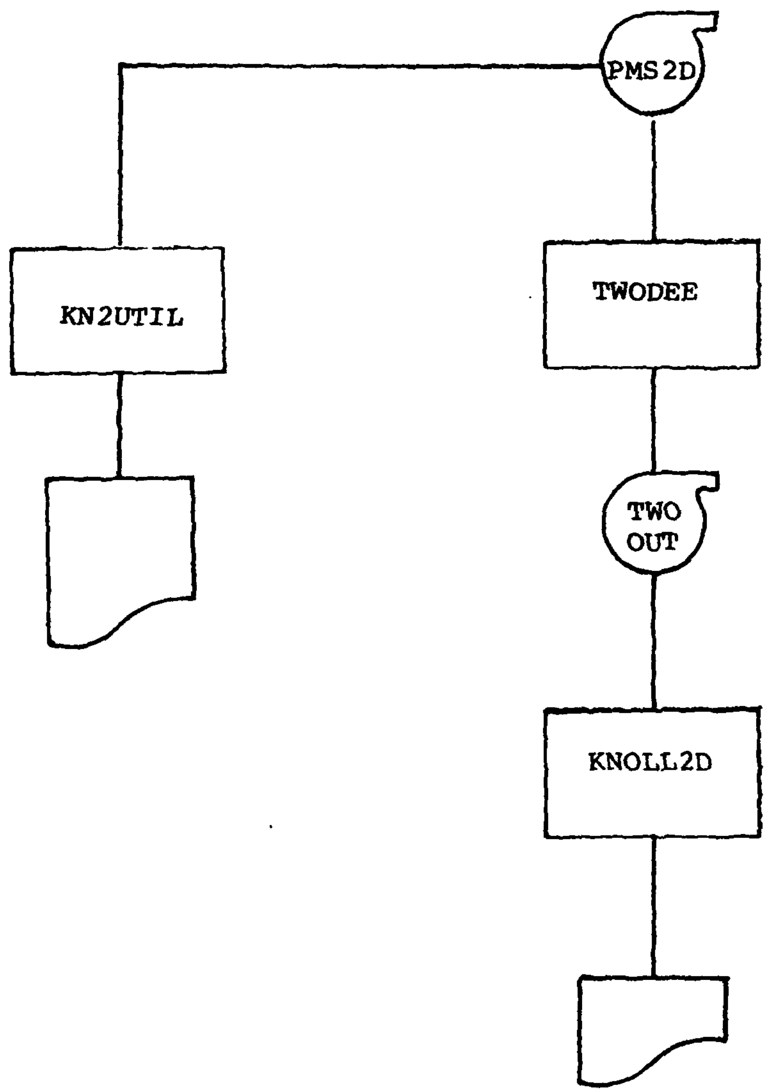
2.3 PMS-2D Data Processing (cont'd)

are processed on the AFGL CDC 6600 computer.

These data tapes contain two types of records, composed of "fast" and "slow" data. The fast data records contain the 2D particle image slices. One dimension, the columns, is represented by the 32 diode array, the other dimension, the rows, by time; i.e. one row represents the diode status for 250 nanoseconds of time. This is true for the MC-130 aircraft; the Learjet row of data occurs every 125 nanoseconds because of the faster speed of the jet.

The slow data records occur once every ten seconds. These records contain VCO and analog information. In addition, selected 1D data is multiplexed into the 2D Buffer and also recorded in the slow data records. The exact information contained in these records is different for each aircraft.

Figure 2.20: PMS-2D Processing Program Flow



2.3.1 Program KN2UTIL

The first area of concern when considering this system is verification of the data collected. KN2UTIL has two methods available to display the data for this purpose. Each has its own advantages and a definite place in the processing stream.

The 6600 line printer output is one means of displaying the observed particles. This printer should be utilized when there are a limited number of records to be examined, or when fast inspection of the data is vital to LYC. One might expect to get two or three of these computer runs per day using the line printer.

This limitation is due to the long record length, and it becomes impractical to print many records. Each record contains 1024 scans of the 32 diode array, yielding approximately 20 computer pages per record. A maximization scheme has been developed which allows three records to be listed using 20 pages. Even with this technique to reduce output lines, a 30 record listing produces 200 pages. Therefore, althought the line printer output offers faster results, its use will have to be limited.

Another method of displaying this data is utilizing the 105mm film plotter available at the computer center. There are, again, advantages and disadvantages of this technique. The primary advantage of using this medium is that several full records may be displayed on a single fiche. Utilization of the film copier available at LYC will provide any hard copies desired. In addition storage of the fiche is

2.3.1 Program KN2UTIL (cont'd)

much more desirable than storing cumbersome computer listings. The only drawback is turn around time. The computer center requires one full day for film processing.

DPSI designed KN2UTIL to take advantage of both media. At the user's option, the desired output device will be used. This allows for both speed and quantity, depending upon the circumstances for data verification.

Because the two record types are interleaved, each record to be listed may be specified in one of two ways, either by overall record number or by sequence number within type (fast or slow). If a tape consists of the following records, the record count is as shown.

	S	S	S	F	F	S	F	F	S	S	F	F	F	F	S	S	F	F	S	F
Record number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Slow sequence #	1	2	3			4			5	6					7	8			9	
Fast sequence #				1	2		3	4			5	6	7	8			9	10		11

Case A. To dump all of the above records either of the following methods should be used.

1. records 1-20

   or

2. Slow records 1-9

   and

   Fast records 1-11

2.3.1 Program KN2UTIL (cont'd)

Case B. To dump the records indicated by the above rectangle use either:

1. records 8-15

    or

2. Slow records 5-7

    and

   Fast records 4-8

Records to be dumped are input via a $SS card in standard namelist format. The record number technique uses prefix A; the slow record, prefix S; and the fast record prefix F. The control variable for the $SS card is REC prefixed with this character, and suffixed with a B or E indicating beginning or end of dump. For the previous two cases the $SS card should be:

Case A.

```
@$SS ARECB=1,ARECE=20 $END
```

or

```
@$SS SRECB=1,SRECE=9,FRECB=1,FRECE=9 $END
```

2.3.1 Program KN2UTIL (cont'd)

Case B.

@$SS ARECB=8,ARECE=15 $END

or

@$SS SRECB=5,SRECE=7,FRECB=4,FRECE=6 $END

where @ = blank column

This program provides a means of verifying the correct operation of the PMS-2D devices. It also produces a data summary that is useful in the manual particle typing required for other analyses. KN2UTIL reads the standard nine track PMS-2D particle image tape (appendix 11 and 12). The program must be run through the 6600 batch processor. Output is in the form of a line printer listing and either CRT or line printer generated images.

To summarize, the following results are produceced by this program:

1. A tape summary of all data recorded that includes
   a. record type (slow or fast)

2.3.1 Program KN2UTIL (cont'd)

b. record length
c. record number (absolute and by type)
d. record time

2. A data listing by record type as specified
   a. slow data - line printer
   b. fast data (on selected device)
      1. line printer
      2. 105mm microfiche

Operating instructions appear in the following section.

2.3.1.1 Program KN2UTIL operating instructions

CONTROL CARDS

```
DPSI,CM75000,T400,NT1.                PROB NO.      NAME
ATTACH,CRT,CRTPLOTS.
LIBRARY,CRT.              1
REQUEST,TAPE39,*Q.
DISPOSE,TAPE39,*FM.
VSN,TAPE1=TAPENO/NT.  (TAPENO IS PMS-2D DATA ACQUISITION TAPE)
REQUEST,TAPE1,PE,L,NR,NT.
FILE(TAPE1,RT=U,BT=K,MRL=5576,MBL=5576,RB=1,BFS=560)
ATTACH,LGO,KN2UTILBIN,ID=GLASS,MR=1.
LDSET,FILES=TAPE1,PRESET=ZERO.
LGO.
EXIT (U)
REWIND,SUM,SOUT,LOUT.
COPY,SUM. 2
COPY,SOUT. 3
COPY,LOUT. 4
7/8/9
DATA
6/7/8/9
```

1 REMOVE WHEN CRT NOT DESIRED (ID CARD COL 1-3 MUST BE BLANK)

2 REMOVE WHEN SUMMARY NOT WANTED

3 REMOVE WHEN SHORT RECORD LISTING NOT WANTED

4 REMOVE WHEN LONG RECORD LISTING NOT WANTED

2.3.1.1 Program KN2UTIL operating instructions (cont'd)

Data Cards

<u>CARD 1</u> ID CARD

```
cc  1-3    PEN FOR CRT OUTPUT
           BLANK FOR LONG RECORD LISTING ON PAPER
cc 11-16   TAPE NUMBER
cc 21-26   FLIGHT DATE   DDMONYR (NO SPACES)
```

<u>CARD 2</u> OPTION CARD

```
cc  2-3    NUMBER OF END OF FILES TO PROCESS (DEFAULT=1)
cc  6-10   NUMBER OF ABSOLUTE RECORDS TO READ (DEFAULT=999999)
```

<u>CARD 3</u> SS NAMELIST CARD*

```
cc  2-4    $ SS
           VALID VARIABLES
           ARECB   ABSOLUTE BEGINNING RECORD
           ARECE   ABSOLUTE ENDING RECORD
           SRECB   BEGINNING SLOW RECORD TO BE LISTED
           SRECE   ENDING SLOW RECORD TO BE LISTED
           LRECB   BEGINNING LONG RECORD TO BE LISTED
           LRECE   ENDING LONG RECORD TO BE LISTED
```

<u>CARD 4</u>

```
cc  2-5    $END
```

<u>CARD 5</u> TIMEFLAG NAMELIST CARD**

```
cc  2-9 $TIMFLAG
           VALID VARIABLES
           TF      CHANGE DEFAULT TIME FLAG CODE
                   (DEFAULT IS TF = 0,1,0,1,0,1,0,1)
```

<u>CARD 6</u>

```
cc  2-5    $END
```

2.3.1.1 Program KN2UTIL operating instructions (cont'd)

* $ SS cards are in standard NAMELIST format. When the ARECB and ARECE variables are specified all records whether they be long or slow that are between records ARECB and ARECE inclusively will be listed. (The ARECB or ARECE variable specifies the actual tape record number).

Specific short and/or long records may be dumped selectively by using the SRECB, SRECE, LRECB and LRECE variables. The example in figure 19 depicts the correct usage.

If the CRT option was selected then the long records will be put onto 105mm fiche.

** $ TIMFLAG cards are in standard namelist format. TF is dimensioned as length = 8. Timing word is indicated by a bit pattern of 01010101 in bits 1-8 of any scan, however due to hardware problems it may be something different. The TIMFLAG cards are a means of changing the flag key AFTER it is known. If the incorrect pattern is 00101010 then the namelist cards should read:

```
@$TIMEFLAG
@TF=0,0,1,0,1,0,1,0,
@$END
```

where @ = blank column

2.3.1.2 Program KN2UTIL sample output

Output details

Figure 2.21 shows the tape summary that is produced whenever KN2UTIL is run. The listing shows the count of each record in terms of both total records and record type. Each long record (indicated by an L in column 1) has a probe identifier (CL for cloud, PR for precip) shown. All long records (particle data) must be 547 words in length. The short records (an S in column 1) must have a length of 86 words. A sync byte (should be 111), a clock time, and an elapsed second counter are all shown for each slow record. Any record that is not either 547 or 86 words is indicated by an X in the left hand column. These records are ignored by all other PMS-2D processing programs.

A short record summary is depicted in figure 2.22. These records contain ten 1-second VCO samples, status words for each probe, and five percent clock rate samples. The eight VCO's that appear at the bottom, are calibrated, and averaged (over 10 seconds) by KN2UTIL: they appear for convenience only and are a means of visually verifying the VCO hardware.

A long record line printer output is shown in figures 2.23 and 2.24. This output is quite lengthy, at one line per scan, a three record set uses approximately 16 pages. At the beginning of each record, the times (clock & elapsed), record count, and overload status are shown. The elapsed time (based on the current clock sample rate) between particles is also shown. Note if a record appears without an

2.3.1.2 Program KN2UTIL sample output (cont'd)

elapsed second count between each particle, there is a good chance that the time flag may be incorrect (see the previous section for a method to correct this). At the end of each record figure 2.24 the elapsed time between particles is summed and printed.

Figure 2.25 also depicts the long records using a dif-rerent media. Each record is shown on one 105mm frame. The information is identical to that on the line printer. The big advantage to this media is the amount of paper used. Whereas the line printer output has a faster (same day, usually) throughput time.

```
$SS
SRECB   = 0,
SRECE   = 30,
LRECB   = 0,
LRECE   = 30,
ARECB   = 0,
ARECE   = 30,
$END
```

Figure 2.21: KN2UTIL output tape summary

```
TIME FLAG IS 01010101
```

S	1111	1	#SHORT	1	20:43:20	530
L	CL	2		1	20:43:29.1	539.114
L	CL	3		2	20:43:30.8	540.760
L	PR	4		3	20:43:31.3	541.278
L	PR	5		4	20:43:34.5	544.494
L	CL	6		5	20:43:34.8	544.794
L	PR	7		6	20:43:33.0	547.971
S	1111	8	#SHORT	2	20:43:30	540
L	CL	9		7	20:43:39.2	549.195
L	CL	10		8	20:43:41.5	551.493
L	PR	11		9	20:43:42.1	552.126
L	CL	12		10	20:43:44.8	554.827
L	PR	13		11	20:43:45.7	555.692
L	CL	14		12	20:43:46.0	556.005
S	1111	15	#SHORT	3	20:43:40	550
L	PR	16		13	20:43:49.2	559.136
L	CL	17		14	20:43:50.6	560.630
L	PR	18		15	20:43:53.6	563.587
L	CL	19		16	20:43:53.9	563.952
L	CL	20		17	20:43:56.9	566.871
L	PR	21		18	20:43:57.6	567.616
S	1111	22	#SHORT	4	20:43:50	560
L	PR	23		19	20:44: 1.2	571.194
L	CL	24		20	20:44: 5.8	575.804
L	PR	25		21	20:44: 6.0	576.033
S	1111	26	#SHORT	5	20:44:00	570
L	CL	27		22	20:44:11.9	581.866
L	PR	28		23	20:44:12.9	582.918

SREC= 13 AREC= 53 AT 659.914 SECONDS

A/C CLOCK		1	2	3	4	5	6	7	8	9	10	11	12		
20:45:20	VCO'S	0	0	0	3994	1644	9755	5086	7167	3294	4618	7859	6577	PCT CLOCK =	7617
20:45:21	VCO'S	0	0	0	3994	1644	9755	5079	7108	3295	4618	7862	6567	PRECIP TOT=	0
20:45:22	VCO'S	0	0	0	3992	1643	9755	5135	7138	3295	4618	7862	6566	PCT CLOCK =	7611
20:45:23	VCO'S	0	0	0	3990	1643	9755	5083	7109	3295	4618	7353	6571	PRECIP TOT=	0
20:45:24	VCO'S	0	0	0	3993	1643	9755	5078	7111	3294	4818	7456	6569	PCT CLOCK =	7698
20:45:25	VCO'S	0	0	0	3986	1643	9754	5080	7111	3295	4818	7354	6561	PRECIP TOT=	0
20:45:26	VCO'S	0	0	0	3980	1642	9755	5082	7115	3294	4818	7852	6556	PCT CLOCK =	7585
20:45:27	VCO'S	0	0	0	3980	1642	9755	5080	7119	3295	4819	7856	6553	PRECIP TOT=	0
20:45:28	VCO'S	0	0	0	3977	1641	9736	5082	7119	3294	4619	7856	6555	PCT CLOCK =	
20:45:29	VCO'S	0	0	0	3977	1640	9760	5082	7118	3295	4619	7363	6547	PRECIP TOT=	

STATUS WORDS

			CLOUD		PRECIP		VCO ID'S		
PCT OV'L'D	0	0	(1)	1	(9)	1	1 PRESSURE	1.034E+01	MB
2D TOTAL	1	0	(2)	1	(10)	1	2 DEL PRESS	2.013E+00	MB
#1 REF V	630	2222	(3)	1	(11)	1	3 TEMP	-8.023E+01	DEG C
#32 REF V	659	3906	(4)	1	(12)	1	4 DEWPOINT	1.111E+02	DEG C
-15V SUPP	1524	1527	(5)	1	(13)	1	5 LWC (JW)	0.	GM/M**3
-12V SUPP	1220	1216	(6)	1	(14)	1	TRUE AIRSP	2.766E+02	KNOTS
+5V SUPP-A	5074	5133	(7)	1	(15)	1	IND AIRSP	5.166E+01	KNOTS
+5V SUPP-B	5008	5150	(8)	1	(16)	1	HEIGHT	2.579E+04	METERS
+15V SUPP	1486	1496							
MIRROR TMP	13	34							

Figure 2.22: KN2UTIL short record summary

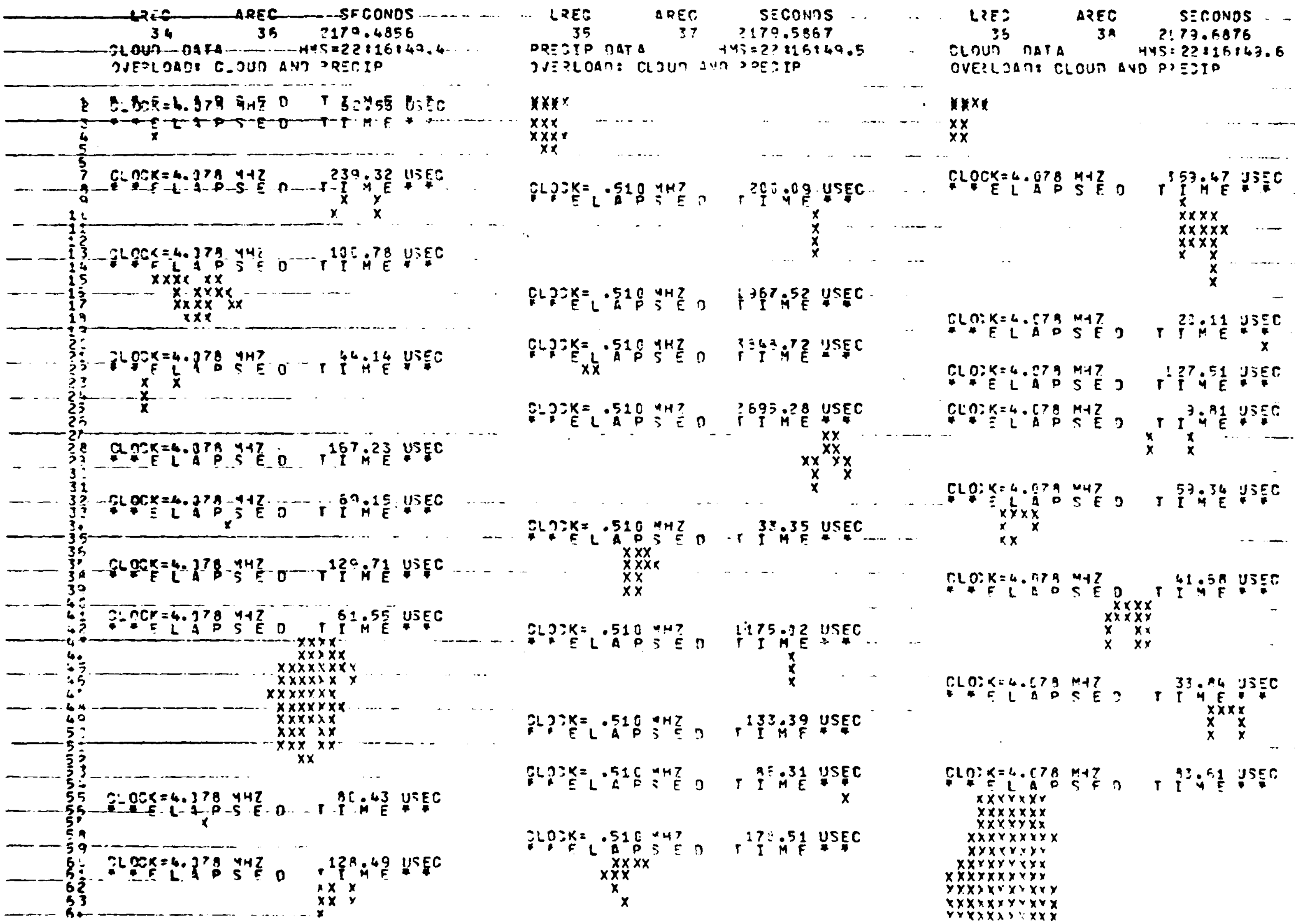


Figure 2.23: KN2UTIL long record summary

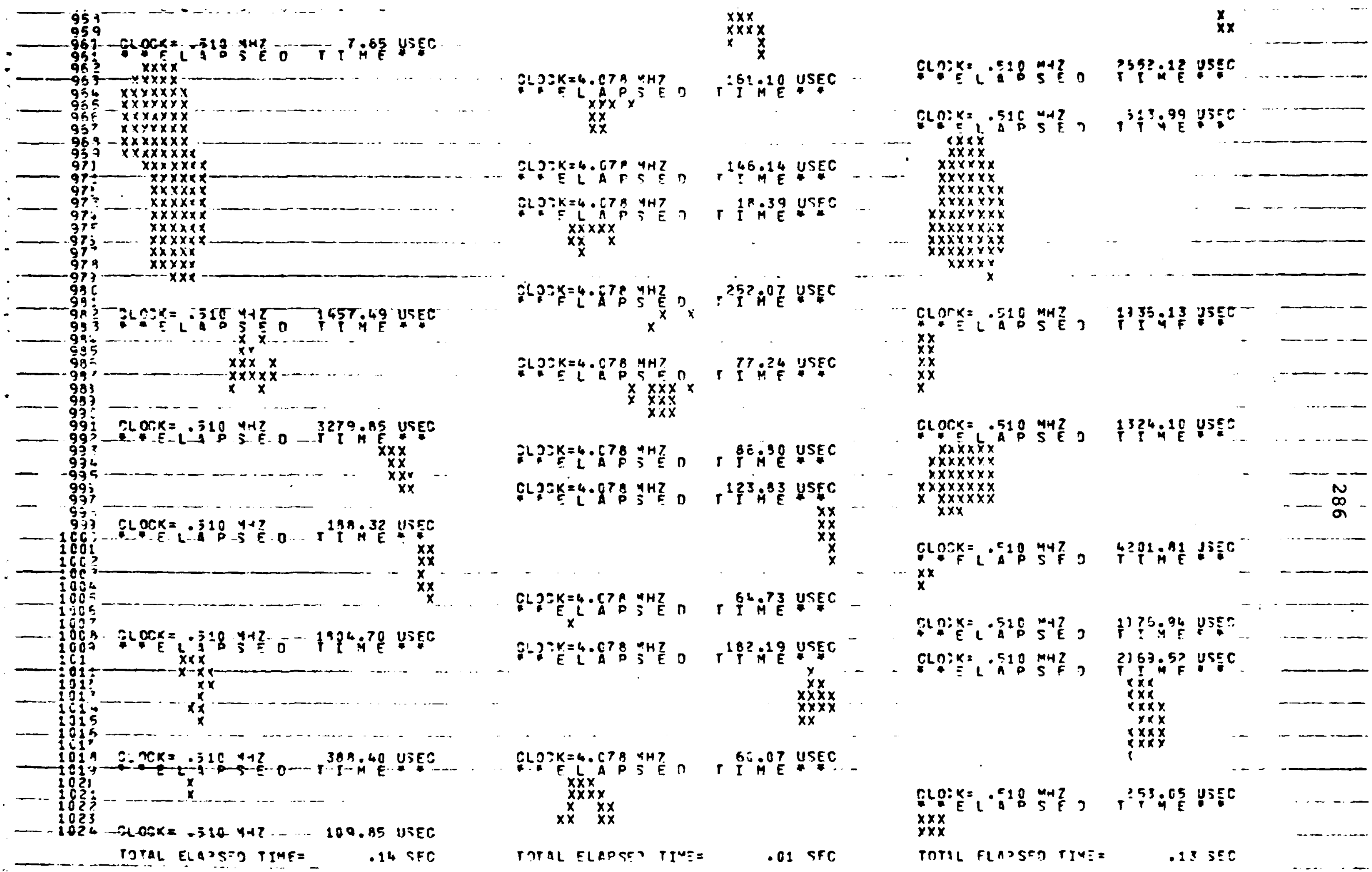
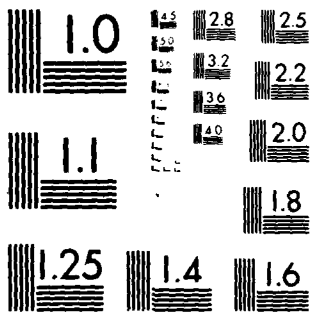


Figure 2.24: Long record summary

AD-A109 929 DIGITAL PROGRAMMING SERVICES INC WALTHAM MASS F/G 4/2
DEVELOPMENT AND APPLICATIONS OF TECHNIQUES TO PROCESS HYDROMETE--ETC(U)
JUL 81 L E BELKSY, F B KAPLAN, J P LALLY F19628-78-C-0131

UNCLASSIFIED AFGL-TR-81-0261 NL

4 OF 7



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

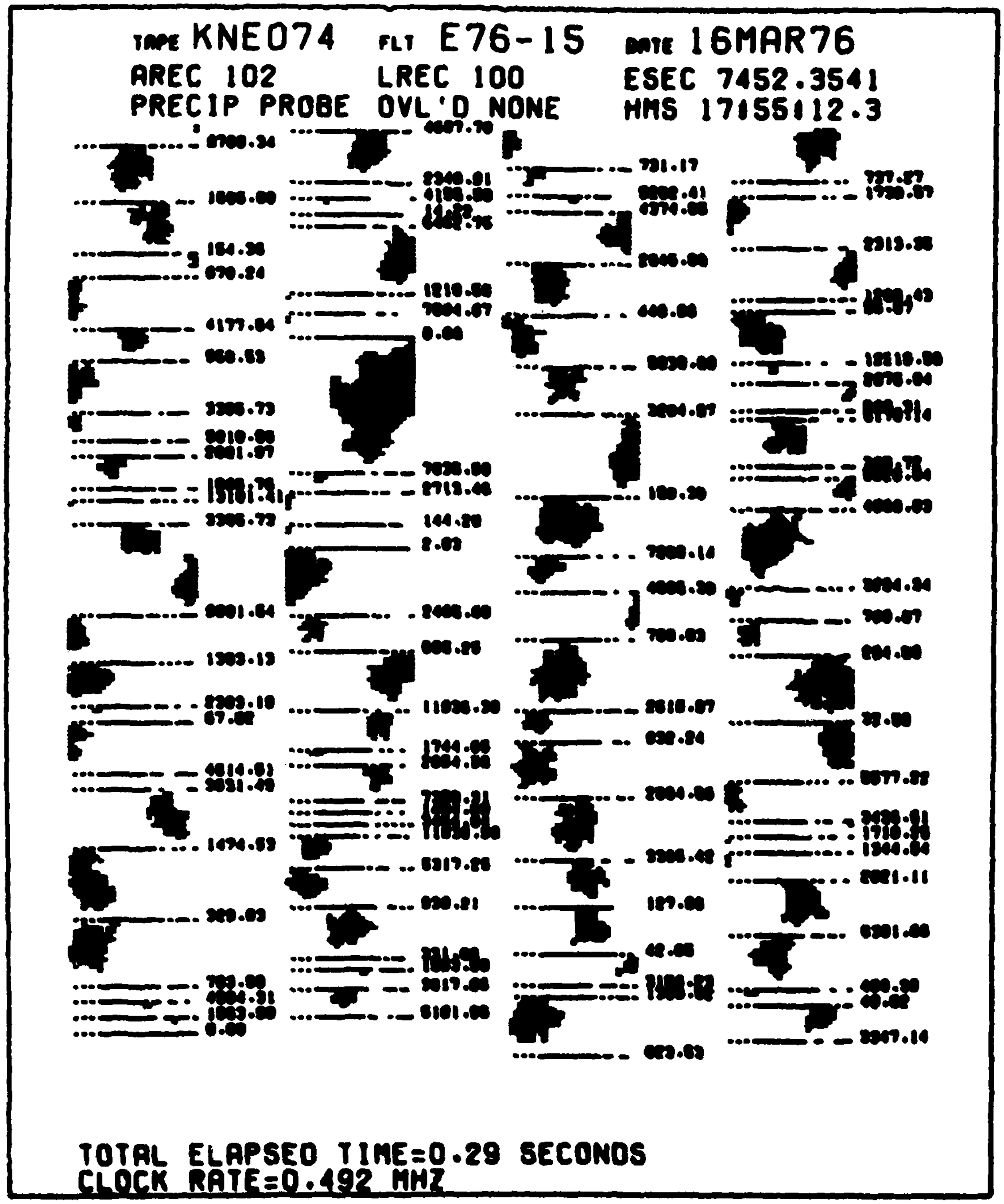


Figure 2.25: KN2UTIL microfiche output

2.3.2 Program TWODEE

The goal of TWODEE is to accept the PMS-2D data acquisition tape and convert the bit patterns into discrete particles described by fundamental parameters. The main problem is how to best determine which diodes can be combined to form a particle. The following sections describe the discrete steps necessary to achieve this objective.

2.3.2.1 Pattern recognition

This area of the program is concerned with transforming the 32 diode scans into actual particles or crystals. The technique developed uses the real time principle of one-pass calculation; that is, while the particle is being determined certain key parameters are also being calculated. This means that after the initial pattern recognition pass, the definition of the particle will have been fully specified. The details of this particle definition, or "signature", are explained in the following sections.

The pattern recognition routine employs a string technique, where a string is defined as a series of consecutive occluded diodes. All the vital information required for each string is stored in one computer word, including (1) particle number or identification, (2) scan number, (3) beginning and (4) ending diode number, and (5) a linkage word. The information is stored as five 12 bit bytes within one 60 bit computer word. Routines are written in COMPASS to insert or extract a particular byte or bytes into the computer word. Although more programming is required using this bit manipulation; it is more desirable than using 5 separate words requiring 5 times as much storage.

Each new string found is checked with strings from the previous scan. If the string is adjacent to a previous one (see figure 2.26A) it is considered a string of the same particle. The new string identification byte must be copied from the previous string identification, thus identifying the new data as an extension of the previous. The old string linkage byte will have to be set to point to the new string word.

Two strings are considered adjacent when one of two

2.3.2.1 Pattern recognition (cont'd)

conditions exist: (1) If two strings have at least one common diode number occluded (the left-hand example of figure 2.26A shows diode #6 occluded in both strings) (2) If two strings have an ending occluded diode and a beginning occluded diode within one number of each other (the right-hand example of figure 2.26A shows the beginning diode #3 in the first string and the ending diode #2 in the second string). In figure 2.26B neither condition exists, and the strings are non adjacent.

```
2345678         123456789
OOXXXOO         OOXXXXXOO
OOOOXXO         XXOOOOOOO
```

X = occluded diode

O = lighted diode

Figure 2.26A Examples of adjacent strings

```
OOOOOXXX        XXXOOOXXX
XXXXOOOO        OOOOXOOOO
```

Figure 2.26B Examples of non adjacent strings

As the scanning progresses certain particles will merge with others (see the stellar example in figure 2.27). The recognition scheme using this definition of adjacent strings accounts for this perfectly, and the particle definition information will be combined. After all 1024 scans have been examined the particles are ready for the next processing step.

2.3.2.1 Pattern recognition (cont'd)

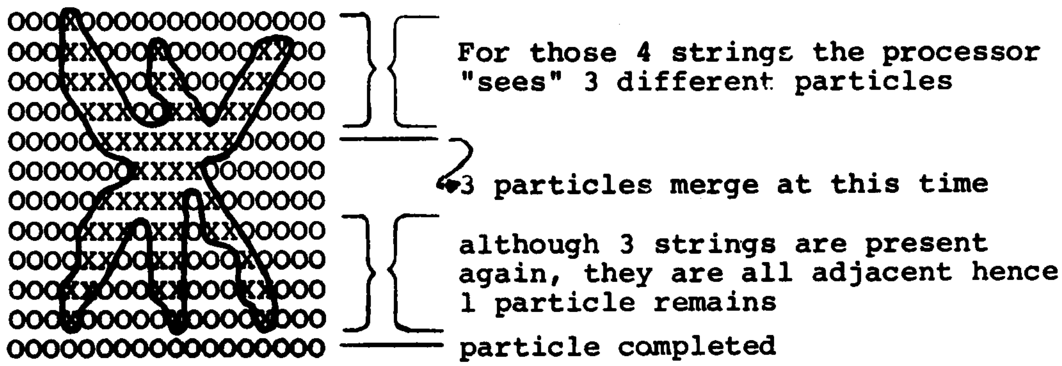


Figure 2.27 Particle merging

The reader should note that only completed particles are processed at this time. A completed particle is defined as a particle completely contained within the 1023 rows in the computer memory. If a particle has a contribution in the 1024th scan it is incomplete. The reasoning for this incompletion is that the particles may have additional strings in the next record. These particles are saved and if necessary merged with the next record. In either case they become the first particles processed in the next record.

When TWODEE was first written any two diodes are part of the same particle if they are immediately adjacent (touching) to each other.

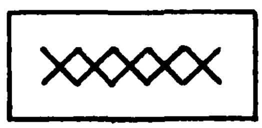
However, in some ICE crystal forms, notably stellars, the laser beam passes completely through parts of the particle. Thus what is really one particle sometimes is processed as more. Therefore, a new method of particle definition was designed.

2.3.2.1 Pattern recognition (cont'd)

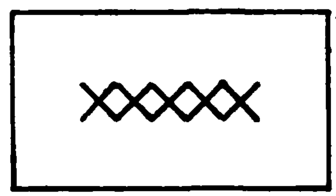
Expanded adjacency considers any two occluded diodes separated by at most one non-occluded diode as belonging to the same particle. Expanded adjacency is used only for ICE type crystals, while standard adjacency (original) is used for RAIN cases.

The increased adjacency criterion is simply a means of keeping shattered ice crystals together.

The right example, below, shows this.



Original Adjacency Requirement



Increased Adjacency Requirement

As can be seen from the example any string within the enclosed box is considered as part of the same particle.
(The particle image is represented by the X's within the boxes).

2.3.2.2 Particle definition

A particle is said to be defined when eight fundamental parameters about it are known. These parameters are: area, perimeter, volume, horizontal projection, horizontal Feret projection, vertical projection, vertical Feret projection, and longest dimension. Five of these are either trivially calculated or a byproduct of the string technique of pattern recognition. The calculations are shown in the following sections.

Before proceeding to a description of these calculations we should discuss the problem of "lost data". When particles are reported, a time delay is caused by the writing of the timing mark to the buffer; this causes 1 to 2 scans to be lost. Indeed successive timing marks can be viewed without any data presented at all. A method has been developed to recreate this lost data.

Each scan of the PMS 2D data system is examined by the data acquisition system. If no diodes were occluded then a counter is maintained which states the number of blank scans seen. When a non blank scan is read, the counter is written to the magnetic tape in a specialized format. This eliminates writing many blank scans to the tape and thus saves tape and processing time in post flight analysis. However, when a non blank scan is detected and the counter is being written, one to two non blank scans are not recorded.

This problem has been handled in the past by using a statistical method to add area to each particle. This method

2.3.2.2 Particle definition (cont'd)

is described by Knollenberg in his PMS FINAL REPORT 1976. Additionally, some particles were never seen and were thus "recreated" by creating a particle of one diode. This occurs when there are two sequential counters reported on the output tape with no particles between them.

These methods did not take into consideration the loss of vertical projections, the possible changing of maximum length and a discrete manner to represent the lost area from each particle.

Many different techniques were discussed and the following method was determined to be the most suitable for our application. Note however that from one to two scans were being lost.

A) If a particle had only one string adjacent to the timing mark, add two scans to the particle. The scan furthest from the original particle (row IR-2, where IR is row of the first string) has length one half the original string centered within the first string's range of diodes. The second scan added (row IR-1) is an exact image of the first string of the particle. See figure 2.28A.

B) If a particle has more than one string on its first row, then duplicate that row about it. See figure 2.28B.

Various problems arose and are listed with their solutions:

2.3.2.2 Particle definition (cont'd)

1) whenever a particle was of one diode long, it had one or two rows added alternately

2) if it was a created particle of one diode, it had only one row added or not every second time

3) if the only string on the scan was of length 2 or 3 only one diode was added on each scan

The replacement method for the one to two strings lost at the beginning of the particle proved to over-adjust the area of each particle. Branch scientists therefore derived a simpler and more efficient algorithm.

Since one to two rows are lost, add one row for every odd numbered particle, add two rows for every even one. Each row to be added will be one half the size of the succeeding row. For example, the first observed row is eight diodes long on an even numbered particle, thus two rows are to be added. The row closest to the eight diode scan is 8/2 = 4 diodes long. The second row to be added is 1/2 the succeeding row (4 diodes) and is thus two diodes long.

An interesting fact is that these additional scans need not be centered in order to give accurate results. In rain cases, with the increase in area calculation, their being centered will provide invalid answers. Thus the added rows are left justified unless the right half of the particle touches diode thirty two (an end diode), in which case the particle is right justified over the succeeding row.

2.3.2.2 Particle definition (cont'd)

```
area added       X
original area    X

                 X
area added       X
original area    X

area added       X
original area    X
                XXX

                  X
area added        X
original area    XX
                 XX

                 X
area added       X
original area  XXX
               XXXX

                 XX
area added     XXXX
original area  XXXX
              XXXXXX

                           XX
area added              XXXXX
original area           XXXXX
                       XXXXXXX
```

Figure 2.28A Example of Lost Data and Regeneration

2.3.2.2 Particle definition (cont'd)

$\frac{\text{area added}}{\text{original area}}$

```
X X
X X
XXX
```

$\frac{\text{area added}}{\text{original area}}$

```
XX  XX
XX  XX
XX  XX
 XXXX
  XX
```

$\frac{\text{area added}}{\text{original area}}$

```
XXX X
XXX X
  XX
```

$\frac{\text{area added}}{\text{original area}}$

```
 X XXXX
 X XXXX
 X XXX
X X X
 X
```

Figure 2.28B Example of Lost Data and Regeneration

2.3.2.3 Area

The area is the total number of diodes occluded by a particle

$$\text{AREA} = \sum \text{number of diodes occluded}$$

For other considerations of area, see Scientific Report[1] #1, Determining the Volume Represented by an Irregularly Shaped Cross-sectional area, 1 Apr 75.

2.3.2.4 Perimeter

The perimeter is calculated as an empirical constant times twice the sum of the horizontal projection plus the vertical projection. Figure 2.29 compares the actual perimeter with the calculated perimeter using

$K_j = 1.$

$P = 2(HP + VP)K_j$ where K_j = a constant for particle type j

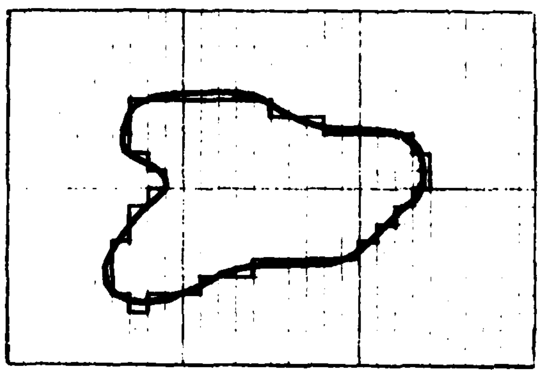


Figure 2.29 Perimeter calculation

---

[1] Determining the Volume Represented by an Irregularly Shaped Cross Sectional Area; Belsky, Lawrence E. (1975)

2.3.2.4 Perimeter (cont'd)

The constant K_j should be calculated empirically since it may be too high for some particle types. Until that time K_j should have a value of one.

2.3.2.5 Horizontal Feret projection

Horizontal Feret projection (HFP) is the longest singular projection in the horizontal direction, i.e. the direction measured by the diode array (along the row) and not by time (along the column). This horizontal Feret projection (figure 2.30) is calculated by taking the largest occluded diode number less the smallest occluded diode number plus 1.

$$HFP = MAX(jf) - MIN(jb) + 1$$

where jf = ending diode numbers
jb = beginning diode numbers

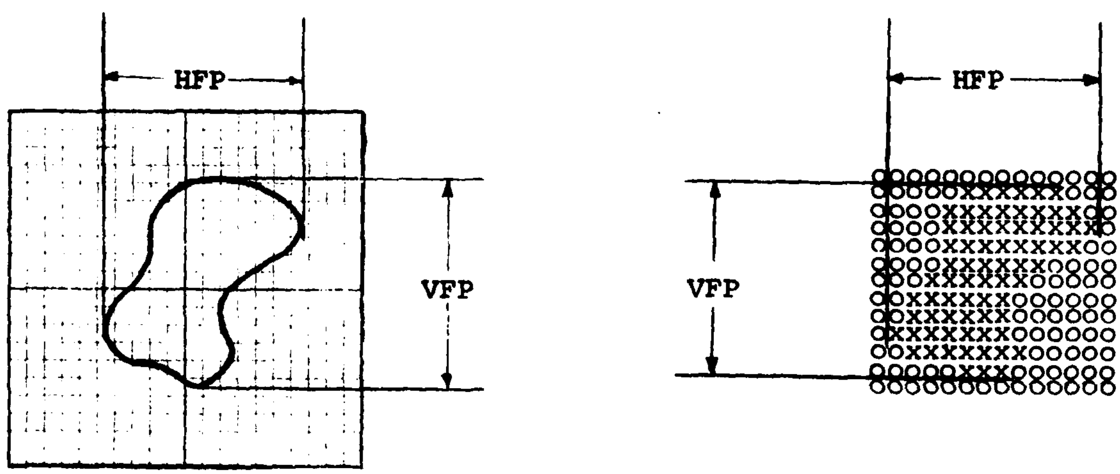


Figure 2.30 Horizontal and vertical Feret projection

2.3.2.5 Horizontal Feret projection (cont'd)

It can be seen in figure 2.30 that the largest jf is 7 and the smallest jb is 2. Substitution into the HFP equation yields:

$$HFP = 13 - 2 + 1 = 12 \text{ diodes}$$

2.3.2.6 Vertical Feret projection

Mathematically the vertical Feret projection (VFP) is similar to the HFP, the difference being the direction of measurement. Time is measured by scan number in the vertical direction. The VFP calculation is the last scan in which a particle appears, less the first scan in which it is see, plus one.

$$VFP = MAX(nr) - MIN(nr) + 1$$

where nr = scan number

Using figure 2.30 the VFP is calculated as ...

$$VFP = 12 - 2 + 1 = 11 \text{ diodes}$$

2.3.2.7 Vertical projection

The vertical projection (VP) is defined as the sum of the partial vertical projections. Figure 2.31 shows this clearly. The equation for this calculation is

$$VP = PVP_1 + PVP_2$$

where PVP = partial vertical projection

2.3.2.7 Vertical projection (cont'd)

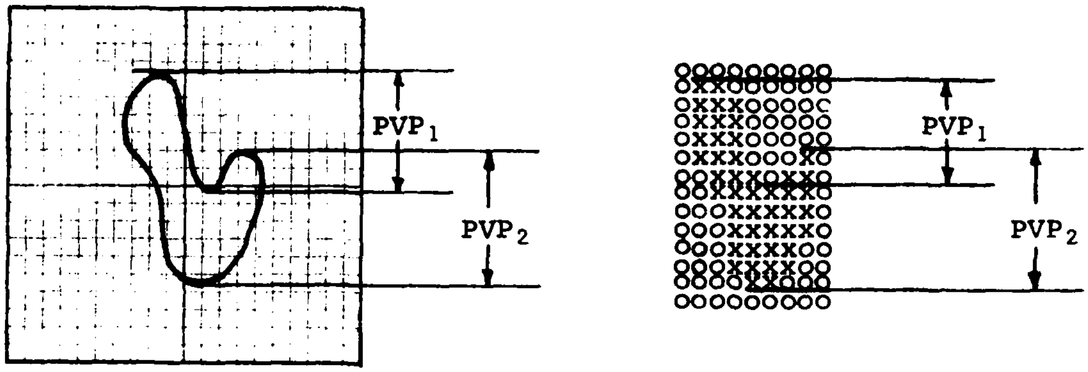


Figure 2.31 Vertical projection

The individual partial projections are quite cumbersome to calculate.

There is an easier way to calculate VP without calculating each partial vertical projection. VP can be ascertained by counting the number of strings that make up a particle. This can be seen by the following.

By examination of figure 2.31 it can be verified that

$PVP_1 = 6$ and
$PVP_2 = 8$

from this the VP is calculated by adding the partial projections:

$$VP = 6 + 8 = 14 \text{ diodes.}$$

However, this is precisely the number of strings that describe this particle.

2.3.2.8 Horizontal projection

The horizontal projection (HP) is, of course, similar to the VP except for direction. A similar analysis can be performed to calculate HP. The particle is examined for strings, not in the "diode" direction, but in the "scan" direction. Again the number of strings found is precisely the horizontal projection.

2.3.2.9 Volume

The volume determination is an area where DPSI has done extensive research. The details and results of this work are published in a scientific report entitled "Scientific Report No. 1; Determining the Volume Represented by an Irregularly Shaped Cross-Sectional Area"[1], 1 April 1975. The method of calculation and results are included here but the reader is referred to the original report for a complete substantiation of the conclusions. The method, simply stated, is to rotate a two dimensional cross-sectional area about its major axis, and calculate the volume generated. A correction is made for particle irregularity by dividing the area into two halves, one above and one below the major axis. Actually each half is rotated about the major axis, and a volume is calculated for each half. The final volume is the average of the two halves.

---

[1] IBID

2.3.2.9 Volume (cont'd)

Consider an irregular shape in two dimensions, whose volume is desired:

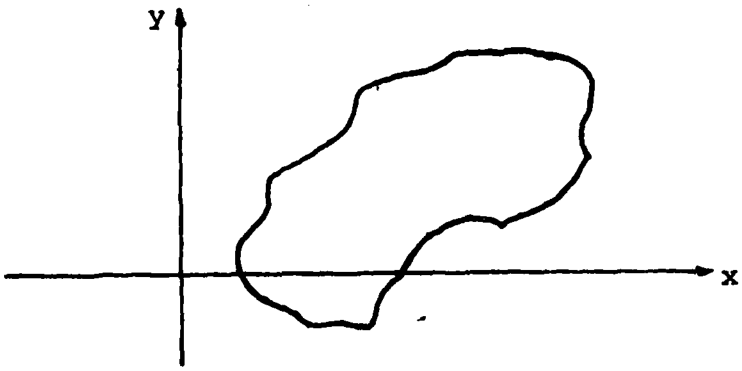


Figure 2.32 Irregularly shaped particle

First, we translate the axes to the center of gravity of the geometric shape. Since the shape is formed by both interior and exterior points, all points are considered. The coordinates of the center of gravity (x_G, y_G) are given by

$$x_G = \sum_k x_i/N$$

$$y_G = \sum_k y_i/N$$

where x_i, y_i are the points along and inside the geometrical figure, and N is the number of x_i, y_i points.

We then form the new points x_i, y_i given by

2.3.2.9 Volume (cont'd)

$$X_i = x_i - x_G$$

$$Y_i = y_i - y_G$$

Our new shape is unchanged by this transformation. The centroid now passes through the origin

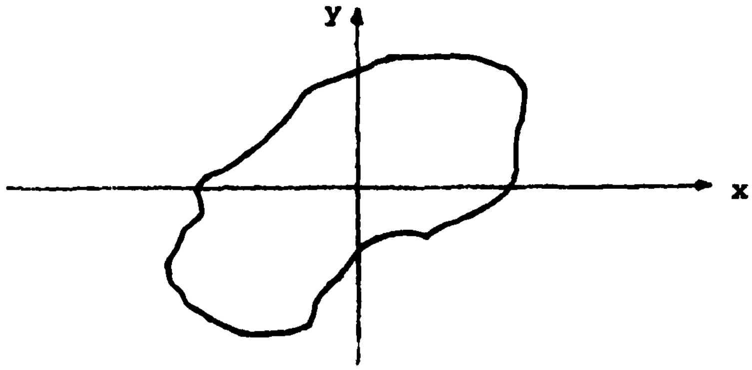


Figure 2.33 Origin at centroid

We now seek the major axis of the shape. This is done in order to rotate about the axis in order to find the volume. From Vector Mechanics (see Beer & Johston, STATICS AND DYNAMICS, McGraw-Hill) the moments of inertia for the shape are given by

$$I_x = \int y^2 dA$$
$$I_y = \int x^2 dA$$
$$I_{xy} = \int xy dA$$

in the discrete case, these equations become

2.3.2.9 Volume (cont'd)

$$I_x = \Sigma\ Y_i^{\,2}\ \Delta m$$
$$I_y = \Sigma\ X_i^{\,2}\ \Delta m$$
$$I_{xy} = \Sigma\ X_i Y_i\ \Delta m$$

I_x, I_y, I_{xy} can be computed at the same time x_G, y_G are done:

$$I_y = \sum (x_i - x_G)^2 = \Sigma\ x_i^{\,2} - 2x_G \Sigma x_i + N x_G^{\,2}$$

Remembering that

$$\Sigma\ x_i = N x_G$$
$$= \Sigma\ x_i^{\,2} - 2N x_G^{\,2} + N x_G^{\,2} = \Sigma\ x_i^{\,2} - N x_G^{\,2}$$

Similarly

$$I_x = \Sigma\ y_i^{\,2} - N y_G^{\,2}$$
$$I_{xy} = \sum (x_i - x_G)(y_i - y_G)$$
$$= \Sigma\ x_i y_i - x_G\ \Sigma y_i - y_G\ \Sigma x_i + N x_G y_G$$
$$= \Sigma\ x_i y_i - N x_G y_G - N x_G y_G + N x_G y_G$$
$$= \Sigma\ x_i y_i - N x_G y_G$$

thus we collect

$$S_x = \Sigma\ x_i \qquad S_y = \Sigma\ y_i$$
$$S_{x^2} = \Sigma\ x_i^{\,2} \qquad S_{y^2} = \Sigma\ y_i^{\,2} \qquad S_{xy} = \Sigma\ x_i y_i$$

2.3.2.9 Volume (cont'd)

then

$$x_G = S_x/N \qquad y_G = S_y/N$$
$$I_y = S_{x^2} - (S_x)^2/N \quad I_x = S_{y^2} - (S_y)^2/N$$
$$I_{xy} = S_{xy} - (S_x)(S_y)/N$$

we seek an angle of rotation θ, such that

$$u_i = X_i \cos\theta + Y_i \sin\theta$$
$$v_i = -X_i \sin\theta + Y_i \cos\theta$$

would force the new uv moment to vanish. That is

$$I_{uv} = \Sigma\, u_i v_i\, \Delta m = 0$$
$$I_{uv} = \Delta m\, \Sigma\, [X_i \cos\theta + Y_i \sin\theta][-X_i \sin\theta + Y_i \cos\theta]=0$$

or

$$\sum (Y_i{}^2 - X_i{}^2)\, \frac{\sin 2\theta}{2} + X_i Y_i \cos 2\theta = 0$$

substituting

$$(I_x - I_y)\, \frac{\sin 2\theta}{2} + I_{xy} \cos 2\theta = 0$$

or

$$\tan 2\theta = 2\left[\frac{I_{xy}}{I_y - I_x}\right]$$

2.3.2.9 Volume (cont'd)

$$\theta = \tfrac{1}{2} \tan^{-1} \left[\frac{2\ I_{xy}}{I_y - I_x}\right]$$

After rotating through the angle θ, we have

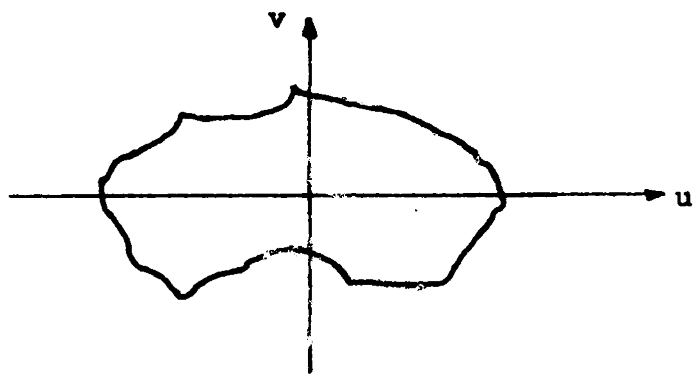


Figure 2.34 Particle rotated to major axes

Now in order to get the volume, we divide the area into two parts

a) all points (u_i, v_i) which lie above $v = 0$

b) all points (u_i, v_i) which lie below $v = 0$

and rotate each half about the u axis. The resulting volume will be the average of the two rotated areas.

Pappus-Guldinus second theorem states: The volume of a body of revolution equals the generating area times the distance traveled by the centroid of the area while the body is being generated.

2.3.2.9 Volume (cont'd)

$$V = 2\pi \bar{v} A'$$

where $\bar{v}$ = the centroid component in the v-direction

A' = area being rotated (since the u-axis bisects the original area, this area is one half ohe original area; $A' = A/2$)

each centroid $\bar{v}$ will be found as

$\bar{v}_1 = \Sigma v_i/k_1$

k_1 = number of points $v_i \geq 0$

$\bar{v}_2 = \Sigma v_i/k_2$

k_2 = number of points $v_i \leq 0$

and assuming the areas A_1 and A_2:

$$\text{Volume}_1 = 2\pi \bar{v}_1 A_1$$

$$\text{Volume}_2 = 2\pi \bar{v}_2 A_2$$

or

$$\text{Volume} = \pi (\bar{v}_1 A_1 + \bar{v}_2 A_2)$$

2.3.2.9 Volume (cont'd)

CONSIDERATION OF THE AREA

As a result of the considerations investigated in Scientific Report #1, the area is best calculated by counting occluded diodes above and below the major axis. When an occluded diode center is conincindent with the major axis, it should be counted in both halves. This report, and the scientific report assumed length dimensions of 1. That is, the distance between diodes multiplied by the distance between successive diode samplings was 1. The final Volume should be

$$\text{Volume} = \pi\ \bar{v}\ N\ (\Delta p)(\Delta x)$$

where Δp = distance between diodes
Δx = sampling distance, determined by Aircraft speed (m/sec) multiplied by time of sampling rate (sec)

CONSIDERATION OF THE ANGLE

The angle of rotation, θ, is given by

$$\theta = \tfrac{1}{2} \tan^{-1} \frac{2I_{xy}}{I_y - I_x}$$

In order to be sure that this rotation will yield the major axis (rather than the minor axis) the arctangent function will be required to produce a result between $-\pi$ and $+\pi$. If the function is limited to a range of $-\frac{\pi}{2}$ and $\frac{\pi}{2}$, the angle will have to be modified by the sign of I_{xy}.

2.3.2.9 Volume (cont'd)

In the former case, the resulting arctangent will be between $-\pi$ and π; Dividing this result by 2 in order to obtain θ will yield

$$-\frac{\pi}{2} < \theta < \frac{\pi}{2}$$

which is proper rotation to insure that u will be the major axis and $v = u + \pi/2$ the minor axis.

Given N points (x_i, y_i) $i = 1,2,3,\ldots,N$

compute

$$S_x = \Sigma\, x_i$$
$$S_y = \Sigma\, y_i$$
$$S_{xx} = \Sigma\, x_i^2$$
$$S_{yy} = \Sigma\, y_i^2$$
$$S_{xy} = \Sigma\, x_i y_i$$
$$x_G = S_x/N$$
$$y_G = S_y/N$$
$$I_y = S_{xx} - S_x^2/N$$
$$I_x = S_{yy} - S_y^2/N$$
$$I_{xy} = S_{xy} - S_x S_y/N$$

$$\theta = \tfrac{1}{2} \tan^{-1} \left\{\frac{2\, I_{xy}}{I_y - I_x}\right\}$$

2.3.2.9 Volume (cont'd)

$$c_1 = \cos\theta$$
$$c_2 = \sin\theta$$

then, for each original point (x_i, y_i)

compute

$$v_i = -c_2(x_i - x_G) + c_1(y_i - y_G)$$

and form

$$S_v = \Sigma\ |v_i|$$
$$k_1 = \text{count all } v_i \geq 0$$
$$k_2 = \text{count all } v_i \leq 0$$

then

$$\bar{v} = S_v / (k_1 + k_2)$$

note: $k_1 + k_2 \geq N$

and

$$\text{Volume} = \pi\ \bar{v}\ N$$

2.3.2.10 Longest dimension

The longest dimension, LMAX, will be found to lie on the major axis. The volume determination, discussed in the previous section, calculates this axis as the u-axis. In addition, all the x,y particle points are transformed to u,v coordinates. The longest dimension is simply the largest u-value less the smallest u-volume plus one. Mathematically this becomes

$$LMAX = MAX(u) - MIN(u) + 1$$

Pictorially this is represented as

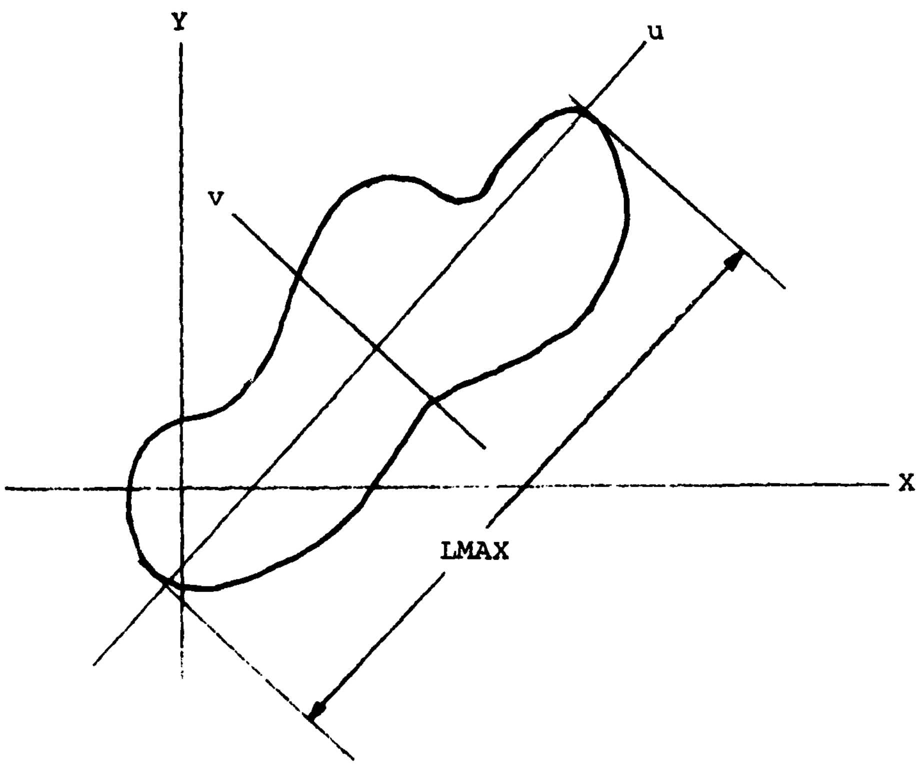


Figure 2.35 Longest dimension

2.3.2.11 Maximum length approximation

In some applications it becomes apparent that the particle volume is not necessary. In the interest of conserving computer time, the volume calculation will be performed optionally. However, the volume calculation does facilitate a simple and direct method of calculating maximum length.

DPSI developed the following maximum length algorithm. Ideally the particles for rain should be spherical, with a circular two-dimensional projection. From figure 2.36 it can be seen that the maximum length is simply LMAX ≈ (HFP + VFP)/2

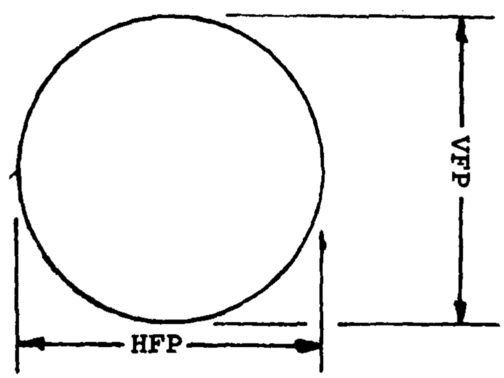


Figure 2.36 Maximum length, spherical particles

For columnar shaped ice crystals an additional problem becomes apparent. Particle orientation should be known, but, as this is a by-product of the volume calculation, it is unavailable. It can be approximated by examining the maximum Feret projection (MFP).

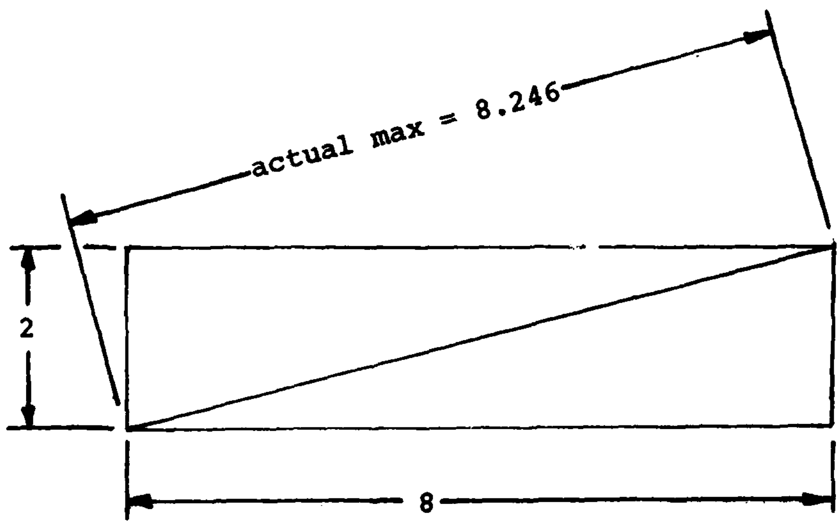
MFP = max(HFP,VFP)

2.3.2.11 Maximum length approximation (cont'd)

With MFP known, the maximum length can be approximated as:

$$LMAX \approx (\sqrt{HFP^2 + VFP^2} + MFP)/2$$

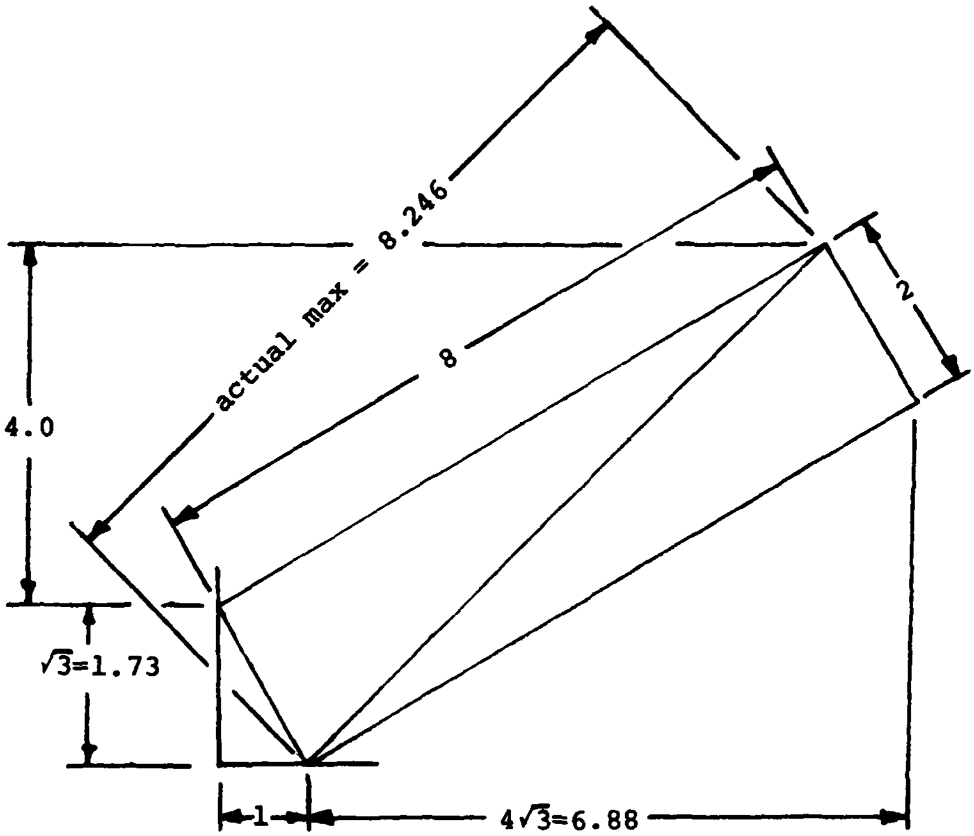
The following examples show the approximation accuracy for various orientations. Note that in all cases the deviation percentage from the three max lengths is considerably less than 10%.



$$L\ max \approx \frac{(8^2 + 2^2)^{\frac{1}{2}} + 8}{2} = 8.12$$

$$\%\ dev = \frac{8.12 - 8.25}{8.25} = -1.58\%$$

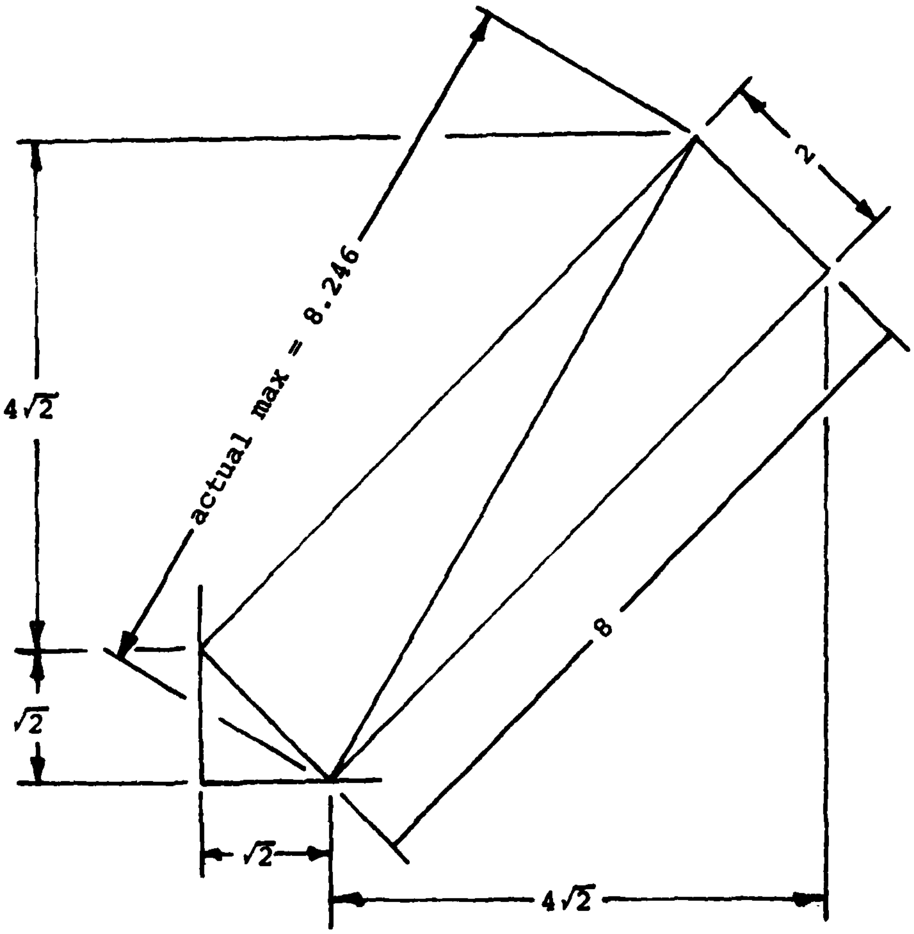
Figure 2.37 Maximum length approximation 0° orientation



$$L\ max \simeq \frac{(5.73^2 + 7.88^2)^{\frac{1}{2}} + 7.88}{2} = 8.81$$

$$\%\ dev = \frac{8.81 - 8.25}{8.25} = 6.8\%$$

Figure 2.38 Maximum length approximation 30° orientation



$$L\ Max \simeq \frac{(7.07^2 + 7.07^2)^{\frac{1}{2}} + 7.07}{2} = 8.53$$

$$\%\ dev = \frac{8.53 - 8.25}{8.25} = 3.5\%$$

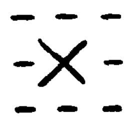
Figure 2.39 Maximum length approximation 0° orientation

2.3.2.12 Particle rejection

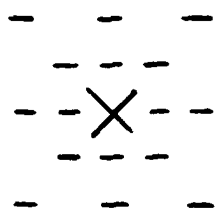
During the original pattern recognition pass the fundamental parameters (see above) are calculated for particles that are not rejected; standard adjacent rain drops and extendedly adjacent ice crystals (see figure 2.40). Empirical testing has been determined a criteria for rejecting processed particles that are invalid because of equipment malfunctions, streakers, etc. This criteria is specified in table 2.1.

EXAMPLES OF TWODEE ADJACENCY TESTS

STANDARD ADJACENCY



EXTENDED ADJACENCY



X OCCLUDED DIODE

\- LOCATION OF AN ADJACENT DIODE

ANY OCCLUDED DIODE IN A POSITION MARKED BY THE SYMBOL "-" IS PART OF THE SAME PARTICLE AS THE OCCLUDED DIODE AT "X"

Figure 2.40: TWODEE adjacency examples

2.3.2.13 Program TWODEE operating instructions

```
CONTROL CARDS
DPSI,CM65000,T2000,NT1.              PROB. NO.      NAME
ATTACH,LL,TIMELFT.
FILE(TAPE1,RT=U,BT=K,MRL=5576,MBL=5576,RB=1,BFS=560) (PERTEC TAPE)
ATTACH,LGO,TWODEEBIN,ID=GLASS,MR=1.
REQUEST,TAPE2,*PF.
VSN,TAPE1=TAPENO/NT.
LDSET,PRESET=ZERO,FILES=TAPE1.
LOAD,LGO,LL.
EXECUTE.
EXIT(U)
CATALOG,TAPE2,TWODDATA,ID=GLASS.
REWIND,TAPE3.
COPY,TAPE3.  (SHORT OR LONG SUMMARY)
REWIND,TAPE4.
COPY,TAPE4.  (PICTURE OUTPUT)
7/8/9
DATA CARDS
6/7/8/9
```

2.3.2.13 Program TWODEE operating instructions (cont'd)

Data Cards

<u>CARD 1</u> IDENTIFICATION CARD

cc 1-6	XYR-NN	FLIGHT ID (COL 1 MUST BE E OR L)
cc 11-19	DDMONYR	FLIGHT DATE

<u>CARD 2</u> OPTION CARD

cc 5	NLEN	0 = FULL CALCULATION OF MAXIMUM LENGTH
		1 = APPROXIMATION OF MAXIMUM LENGTH
cc 6-10	NEOF	NUMBER OF END OF FILES TO PROCESS
cc 11-15	NOUT	0 = SUMMARY OUTPUT
		1 = FULL OUTPUT
cc 16-20	NRST	NUMBER OF FEET USED IN PREVIOUS EXECUTION (USED FOR RESTARTING JOB)
cc 21-25	NTSW*	0 = USE REAL TIME CLOCK
		1 = INPUT TIME OF FIRST SLOW RECORD
cc 76-80	NFEET	NUMBER OF FEET ON CURRENT REEL (DEFAULT 2400)

<u>CARD 3- N</u> PASS CARDS

cc 2-9	HH:MM:SS	SAMPLING START TIME
cc 12-19	HH:MM:SS	SAMPLING STOP TIME
cc 25	QTYPE	= I IF SNOW OR ICE IN PASS
		= R IS ONLY RAIN IN PASS
cc 30	DPROBE	= 2 SHUT OFF CLOUD PROBE
		= 3 SHUT OFF PRECIP PROBE

* IF NTSW=1 NEXT CARD MUST BE A TIME CARD IN FORMAT @HH:MM:SS WHERE @ = BLANK COLUMN

2.3.2.14 Program TWODEE sample output

Output Details

Figure 2.41 depicts the short particle tape summary listing. There is one row of information per record. This includes: record number and length, clock time, record number from the nine track tape, slow record number, sample time and rate, aircraft, probe and overload information, and also six VCO counts.

The full particle tape summary (figure 2.42) includes all of the above in addition to the fundamental parameters for each particle contained within the record. In this listing the header information is shown in the two half-lines at the top. Each full line contains the particle parameters.

Figure 2.43 is a picture summary showing 3 states of the particle reconstruction process. It is tape 4 from the operating instructions.

NUMBER	PARTICLE TYPE	CRITERIA
1	BOTH	MORE THAN ONE PARTICLE BETWEEN SUCCESSIVE TIME MARKS
2	BOTH	REJECT CONSECUTIVE TIME MARKS AFTER KEEP-ING ONLY THE FIRST
3	BOTH	REJECT ANY PARTICLE WHOSE AREA IS GREATER THAN 1500 DIODES
4	ICE	REJECT IF VERTICAL FERET PROJECTION EX-CEEDS 30 DIODES
5	RAIN	REJECT IF VERTICAL FERET PROJECTION EX-CEEDS 31 DIODES
6	RAIN	REJECT IF THE FOLLOWING TWO CONDITIONS ARE MET: A) HORIZONTAL FERET PROJECTION LESS THAN 24 B) VERTICAL FERET PROJECTION GREATER THAN SIX TIMES HORIZONTAL FERET
7	RAIN	REJECT IF THE FOLLOWING TWO CONDITIONS ARE MET: A) HORIZONTAL FERET LESS THAN SIX B) NOT TOUCHING AN EDGE & VERTICAL FERET GREATER THAN THREE TIMES HORIZONTAL FERET
8	RAIN	REJECT IF AREA LESS THAN 0.4 TIMES HORI-ZONTAL FERET TIMES VERTICAL FERET
9	RAIN	REJECT IF AREA LESS THAN OR EQUAL TO 5 AND VERTICAL FERET PROJECTION LESS THAN THREE TIMES THE HORIZONTAL FERET PRO-JECTION
10	RAIN	REJECT IF ALL THE FOLLOWING ARE TRUE A) AREA GREATER THAN FIVE B) MEND=0 C) VERTICAL FERET PROJECTION IS GREATER THAN OR EQUAL TO ONE AND ONE HALF TIMES THE HORIZONTAL PROJECTION, OR, VICE VERSA

Table 2.1: TWODEE rejection criteria

NUMBER	PARTICLE TYPE	CRITERIA
11	RAIN	REJECT IF THE FOLLOWING CONDITIONS ARE MET: A) AREA GREATER THAN 5 B) MEND GREATER THAN 0 C) VERTICLE FERET PROJECTION IS LESS THAN OR EQUAL TO MEND D) VERTICLE FERET PROJECTION IS GREATER THAN OR EQUAL TO ONE AND ONE-HALF TIMES THE HORIZONTAL FERET PROJECTION, OR,VICE VERSA.
12	RAIN	REJECT IF THE FOLLOWING ARE TRU A) AREA GREATER THAN 5 B) MEND GREATER THAN 0 C) VERTICLE FERET PROJECTION IS GREATER THAN OR EQUAL TO TWO AND ONE-HALF TIMES THE HORIZONTAL FERET PROJECTION, OR, VICE VERSA.

NOTE: MEND=THE MAXIMUM OF THE NUMBER OF DIODES TOUCHING THE LEDT AND RIGHT SIDES OF THE SCAN.

Table 2.1: TWODEE rejection criteria (cont'd)

RECORD	WORDS	HH:MM:SS.F	SPEC&FREQ	SAMPL--MS	CLKRTE-KK	AC&PROBE	OVERLOAD	PRESS	DEL P	TEMP	DEWPT	TAS	JW-LWC
1	512	22:22: 9.8	600007	2597	82429	3	0	327508189	6435	6265	5344	4242	502
2	512	22:22: 9.8	600007	2597	82429	3	0	327508189	6435	6265	5344	4242	502
3	92	22:22: 9.8	600007	2597	82429	3	0	327508189	6435	6265	5344	4242	502
4	352	22:22:10.8	600008	1486	82429	2	0	327508189	6435	6265	5344	4242	502
5	512	22:22:11.8	600009	1172	82429	2	0	327508189	6435	6265	5344	4242	502
6	62	22:22:11.8	600009	1172	82429	2	0	327508189	6435	6265	5344	4242	502
7	512	22:22:12.8	600010	2793	82429	3	2	327508189	6435	6265	5344	4242	502
8	512	22:22:12.8	600010	2793	82429	3	2	327508189	6435	6265	5344	4242	502
9	252	22:22:12.8	600010	2793	82429	3	2	327508189	6435	6265	5344	4242	502
10	512	22:22:13.8	600011	2003	82429	2	10	327508189	6435	6265	5344	4242	502
11	512	22:22:13.8	600011	2003	82429	2	10	327508189	6435	6265	5344	4242	502
12	62	22:22:13.8	600011	2003	82429	2	10	327508189	6435	6265	5344	4242	502
13	512	22:22:14.8	600012	2075	82429	3	8	327508189	6435	6265	5344	4242	502
14	512	22:22:14.8	600012	2075	82429	3	8	327508189	6435	6265	5344	4242	502
15	212	22:22:14.8	600012	2075	82429	3	8	327508189	6435	6265	5344	4242	502
16	512	22:22:15.8	600013	972	82429	2	8	327508189	6435	6265	5344	4242	502
17	112	22:22:15.8	600013	972	82429	2	8	327508189	6435	6265	5344	4242	502
18	512	22:22:15.8	600014	1724	82429	3	10	327508189	6435	6265	5344	4242	502
19	512	22:22:16.8	600014	1724	82429	3	10	327508189	6435	6265	5344	4242	502
20	92	22:22:16.8	600014	1724	82429	3	10	327508189	6435	6265	5344	4242	502
21	392	22:22:17.8	600015	1809	82429	2	10	327508189	6435	6265	5344	4242	502
22	512	22:22:18.8	600016	1229	82429	3	10	327508189	6435	6265	5344	4242	502
23	332	22:22:19.8	600016	1229	82429	3	10	327508189	6435	6265	5344	4242	502
24	272	22:22:19.8	1700019	662	83195	2	10	326808189	6455	6322	5346	4268	502
25	512	22:22:20.8	1700019	985	83195	3	8	326808189	6455	6322	5346	4268	502
26	152	22:22:20.8	1700019	985	83195	3	8	326808189	6455	6322	5346	4268	502
27	442	22:22:21.8	1700020	2211	83195	2	8	326808189	6455	6322	5346	4268	502
28	512	22:22:22.8	1700021	1823	83195	3	10	326808189	6455	6322	5346	4268	502
29	512	22:22:22.8	1700021	1823	83195	3	10	326808189	6455	6322	5346	4268	502
30	232	22:22:22.8	1700021	1823	83195	3	10	326808189	6455	6322	5346	4268	502
31	512	22:22:23.8	1700022	1408	83195	2	10	326808189	6455	6322	5346	4268	502
32	22	22:22:23.8	1700022	1408	83195	2	10	326808189	6455	6322	5346	4268	502
33	512	22:22:24.8	1700023	2119	83195	3	10	326808189	6455	6322	5346	4268	502
34	512	22:22:24.8	1700023	2119	83195	3	10	326808189	6455	6322	5346	4268	502
35	32	22:22:24.8	1700023	2119	83195	3	10	326808189	6455	6322	5346	4268	502
36	512	22:22:25.8	1700024	362	83195	2	2	326808189	6455	6322	5346	4268	502
37	512	22:22:26.8	1700025	2066	83195	3	2	326808189	6455	6322	5346	4268	502
38	512	22:22:26.8	1700025	2066	83195	3	2	326808189	6455	6322	5346	4268	502
39	312	22:22:26.8	1700025	2066	83195	3	2	326808189	6455	6322	5346	4268	502
40	512	22:22:27.8	1700026	792	83195	2	2	326808189	6455	6322	5346	4268	502
41	192	22:22:27.8	1700026	792	83195	2	2	326808189	6455	6322	5346	4268	502
42	512	22:22:28.8	1700027	1207	83195	3	2	326808189	6455	6322	5346	4268	502
43	452	22:22:28.8	1700027	1207	83195	3	2	326808189	6455	6322	5346	4268	502
44	512	22:22:29.8	2800029	135	82589	2	10	326208190	6442	6290	5367	4245	503
45	72	22:22:29.8	2800029	135	82589	2	10	326208190	6442	6290	5367	4245	503
46	512	22:22:30.8	2800030	618	82589	3	10	326208190	6442	6290	5367	4246	503
47	232	22:22:30.8	2800030	618	82589	3	10	326208190	6442	6290	5367	4245	503
48	512	22:22:31.8	2800031	1026	82589	2	10	326208190	6442	6290	5367	4246	503
49	512	22:22:32.8	2800032	2122	82589	3	10	326208190	6442	6290	5367	4246	503
50	512	22:22:32.8	2800032	2122	82589	3	10	326208190	6442	6290	5367	4246	503

Figure 2.41: Short particle tape listing

RECORD	162		512 WORDS						
HH:MM:SS.F	SREC&FREQ	SAMPLE-MS	CLKRTE-%K	AC&PROBE	OVERLOAD				
PRESS	DEL P	TEMP	DEWPT	TAS	JW-LWC				
10:18:35.0	12100182	115	95835	3	10				
596208233	1	1	353-	6	5500				
AREA	PERIM	HF PROJ	VF PROJ	H PROJ	V PROJ	UNUSED	UMAX	THETA	VOLUME
-88	52	8	17	6	18	0	17.89	0.00	0.00
-28	28	5	6	6	8	0	8.72	0.00	0.00
54	38	8	11	8	11	0	11.46	0.00	0.00
-83	45	7	15	6	16	0	15.78	0.00	0.00
-7	16	2	6	2	6	0	6.16	0.00	0.00
1	4	1	1	1	1	0	1.21	0.00	0.00
1	4	1	1	1	1	0	1.21	0.00	0.00
-51	34	7	9	7	10	0	10.20	0.00	0.00
12	22	4	4	5	6	0	4.83	0.00	0.00
16	30	5	6	6	9	0	6.91	0.00	0.00
-23	24	4	8	4	8	0	8.47	0.00	0.00
14	24	5	5	5	7	0	6.04	0.00	0.00
-25	24	4	7	5	7	0	7.53	0.00	0.00
36	30	7	8	7	8	0	9.32	0.00	0.00
-8	12	3	3	3	3	0	3.62	0.00	0.00
62	38	9	10	9	10	0	11.73	0.00	0.00
2	6	1	2	1	2	0	2.12	0.00	0.00
-55	46	5	15	5	16	0	15.41	0.00	0.00
38	28	7	7	7	7	0	8.45	0.00	0.00
98	52	9	14	11	15	0	15.32	0.00	0.00
2	6	1	2	1	2	0	2.12	0.00	0.00
16	30	5	6	6	9	0	6.91	0.00	0.00
-35	72	9	23	11	25	0	23.65	0.00	0.00
58	42	9	10	9	12	0	11.73	0.00	0.00
-20	26	3	9	4	9	0	9.24	0.00	0.00
-74	46	6	17	6	17	0	17.51	0.00	0.00
9	18	3	5	4	5	0	5.42	0.00	0.00
2	6	1	2	1	2	0	2.12	0.00	0.00
-34	32	5	11	5	11	0	10.59	0.00	0.00
-94	46	8	13	9	14	0	14.13	0.00	0.00
-53	42	6	11	6	13	0	12.30	0.00	0.00
-16	26	4	6	5	8	0	6.61	0.00	0.00
-21	32	5	9	6	11	0	9.65	0.00	0.00
92	46	11	12	11	12	0	14.14	0.00	0.00
-154	73	16	14	16	19	0	18.63	0.00	0.00
-1	4	1	1	1	1	0	1.21	0.00	0.00
87	56	9	14	10	15	0	15.32	0.00	0.00
-12	22	2	9	2	9	0	9.11	0.00	0.00
-45	33	6	5	6	9	0	9.91	0.00	0.00
128	72	13	12	16	23	0	15.35	0.00	0.00
14	26	5	4	6	7	0	5.79	0.00	0.00
10	16	6	2	6	2	0	6.16	0.00	0.00
134	58	12	15	12	17	0	18.00	0.00	0.00
-1	4	1	1	1	1	0	1.21	0.00	0.00
-51	32	8	7	5	7	0	9.32	0.00	0.00
-57	38	6	10	6	11	0	11.40	0.00	0.00
-44	30	6	9	6	9	0	9.91	0.00	0.00
203	76	14	22	16	22	0	24.04	0.00	0.00
25	22	5	6	5	6	0	6.91	0.00	0.00
-73	44	9	11	9	13	0	12.61	0.00	0.00

Figure 2.42: Full particle tape summary

Figure 2.43: Picture summary

```
RECORD    22 AT 20:44: 1.2

                            AREA    PERIM      HFP     VFP     HP       VP      VE    LMAX     ECR      APR
FOR PARTICLE=  1             -3       8          1       3      1        3       3   2.000   1.303    1.000
          --------------------------------  ------------------------------  ------------------------------
   6  !                              ! !                              ! !X                             !
   7  !X                             ! !X                             ! !X                             !
   8  !X                             ! !X                             ! !X                             !
      ================================  ================================  ==============================
FOR PARTICLE=  3             22      22          5       6      5        6       0   5.500   1.323    1.000
          --------------------------------  ------------------------------  ------------------------------
  21  !                              ! !                              ! !   XXX                        !
  22  !    XXXXX                     ! !    XXXXX                     ! !   XXXXX                      !
  23  !    XXXXX                     ! !    XXXXX                     ! !   XXXXX                      !
  24  !    XXXXX                     ! !    XXXXX                     ! !   XXXXX                      !
  25  !     XXX                      ! !     XXX                      ! !    XXX                       !
  26  !      X                       ! !      X                       ! !     X                        !
      ================================  ================================  ==============================
FOR PARTICLE=  6            -10      14          4       3      4        3       3   3.500   1.249    1.000
          --------------------------------  ------------------------------  ------------------------------
  37  !                              ! !                              ! !XX                            !
  38  !XX X                          ! !XXXX                          ! !XXXX                          !
  39  !XXXX                          ! !XXXX                          ! !XXXX                          !
      ================================  ================================  ==============================
FOR PARTICLE=  8             33      26          7       6      7        6       0   6.500   1.277    1.000
          --------------------------------  ------------------------------  ------------------------------
  50  !                              ! !                              ! !  XXX                         !
  51  !   XXXXXX                     ! !  XXXXXX                      ! !  XXXXXX                      !
  52  !  XXXXXXX                     ! ! XXXXXXX                      ! ! XXXXXXX                      !
  53  !  XXXXXXX                     ! ! XXXXXXX                      ! ! XXXXXXX                      !
  54  !   XXXXXX                     ! !  XXXXXX                      ! !  XXXXXX                      !
  55  !    XXXX                      ! !   XXXX                       ! !   XXXX                       !
      ================================  ================================  ==============================
FOR PARTICLE= 10             -6      12          3       3      3        3       3   3.000   1.382    1.000
          --------------------------------  ------------------------------  ------------------------------
  58  !                              ! !                              ! !X                             !
  59  !                              ! !                              ! !XX                            !
  60  !X X                           ! !XXX                           ! !XXX                           !
      ================================  ================================  ==============================
FOR PARTICLE= 11             27      24          6       6      6        6       0   6.000   1.303    1.000
          --------------------------------  ------------------------------  ------------------------------
  64  !                              ! !                              ! !        XXX                   !
  65  !         XXXXXX               ! !         XXXXXX               ! !        XXXXXX                !
  66  !         XXXXXX               ! !         XXXXXX               ! !        XXXXXX                !
  67  !         XXXXXX               ! !         XXXXXX               ! !        XXXXXX                !
  68  !          XXXXX               ! !          XXXXX               ! !         XXXXX                !
  69  !            X                 ! !            X                 ! !          X                   !
      ================================  ================================  ==============================
```

2.3.3 Program KNOLL2D

KNOLL2D takes the particle tape produced by TWODEE and quantifies it based upon user pass inputs, including determination of particle type. KNOLL2D generates concentration tables based upon each of the fundamental parameters discussed in the section on TWODEE. Using the largest diameter of each particle, it also produces a distribution similar to that produced by KNOLL1D.

2.3.3.1 Program KNOLL2D operating instructions

```
KNOLL2D CONTROL CARDS
DPSI,CM65000,T200,TP2.*                    ACT #     NAME
ATTACH,LGO,KNOLL2DBIN,ID=GLASS,MR=1.
REQUEST,TAPE1,MT,VSN=LYCXXX.
REQUEST,TAPE2,MT,RING,VSN=LYCXXX.*
MAP,OFF.
LDSET,PRESET=ZERO.
LGO.
EXIT(U)
REWIND,TAPE3,TAPE9.
COPY,TAPE3.
COPY,TAPE9.
7/8/9
-ID CARD-
-$SCOEF-
-$VCOEF-
-$JWADJ-
-OPTION-
-TYPE-ATOD-XTOD-
6/7/8/9
```

*   IF NO OUTPUT TAPE IS DESIRED CHANGE TP2 TO TP1
AND REMOVE REQUEST,TAPE2 CARD

2.3.3.1 Program KNOLL2D operating instructions (cont'd)

KNOLL2D DATA CARDS

CARD 1 ID CARD

cc 1-10 FLT XYR-NN (X MUST BE AN E OR L IN COLUMN 5)

11-20 DD MON YR

21-30 INPUT TAPE NUMBER

31-40 OUTPUT TAPE NUMBER

CARD 2 $SCOEF

NAMELIST CARD FOR SOUNDING COEFFICIENTS.

VARIABLE IS: S(J) WHERE J=1,2,3,4,5 AND

HT = S(5)*PRES**4+S(4)*PRES**3+S(3)*PRES**2+
S(2)*PRES + S(1)

CARD 3 $VCOEF

NAMELIST CARD FOR VCO CALIBRATIONS.

VARIABLE IS: C(I,J) I = 1 INTERCEPT,
I = 2 SLOPE, I = 3 THIRD ORDER

J	VARIABLE
1	INDICATED AIRSPEED
2	TEMPERATURE
5	DEWPOINT
6	JW-LWC
7	NOT USED
8	PRESSURE (KISTLER)
9	TRUE AIRSPEED
3,4,10,11,12,13	NOT USED

CARD 4 $JWADJ

JW-LWC ADJUSTMENT PROFILES

L
HT(10)
SLA(10)
XA(10)

2.3.3.1 Program KNOLL2D operating instructions (cont'd)

CARD 5	OPTION CARD
CC 16-20	= 0 NO OUTPUT TAPE
	= 1 MAKE OUTPUT TAPE
CC 26-30	= 0 USE KISTLER PRESSURE
	= 1 USE BACKUP PRESSURE
CC 61-35	= 0 USE CALCULATED AIRSPEED
	= 1 USE TAS
CARD 6	EITHER A TYPE, ATOD, OR AN XTOD CARD TYPE (15 MAXIMUM - AT LEAST ONE)
CC 1-4	TYPE
CC 6-13	START TIME IN FORM HH:MM:SS
CC 16-23	STOP TIME IN FORM HH:MM:SS
CC 25-26	PARTICLE TYPE FOR CLOUD PROBE (I2)
CC 27-28	PARTICLE TYPE FOR PRECIP PROBE (I2)
CC 31-35	AVERAGING INTERVAL (I5)

XTOD CARDS DESCRIPTION (OPTIONAL - NO MAXIMUM)

The XTOD cards are used to change the default coefficients exponent (ex), or breakpoint (C) for each equivalent melted diameter equation. For example, to change the third exponent for particle type 23 (RIMED DENDRITES) from 1.0 to 0.9 the following XTOD card is required:

CC	VALUE	DESCRIPTION
1-4	XTOD	CARD CODE (FIXED)
6-7	23	PARTICLE TYPE
9-10	03	THIRD EQUATION
12-13	02	EXPONENT
15-30	0.9	NEW VALUE

2.3.3.1 Program KNOLL2D operating instructions (cont'd)

ATOD CARDS DESCRIPTION (OPTIONAL - NO LIMIT)

The ATOD cards are used to change the default coefficient exponent (ex), or breakpoint (C) for each equivalent melted diameter equation. For example, to change the third exponent for particle type 23 (RIMED DENDRITES) from 1.0 to 0.9 the following XTOD card is required:

CC	VALUE	DESCRIPTION
1-4	ATOD	CARD CODE (FIXED)
6-7	23	PARTICLE TYPE
9-10	03	THIRD EQUATION
12-13	02	EXPONENT
15-30	0.9	NEW VALUE

XTOD CARDS CHANGE THE DEFAULT MAXIMUM LENGTH TO EQUIVALENT MELTED DIAMTER EQUATIONS.

ATOD CARDS CHANGE THE DEFAULT AREA TO EQUIVALENT MELTED DIAMETER EQUATIONS.

2.3.3.2 Program KNOLL2D sample output

Output Details

The first type of output produced by KNOLL2D is similar to that produced by KNOLL1D. All references made are to figure 2.44.

A) The number of one second data samples that were averaged to make this table

B) the start and stop time of this interval

C) flight identification

D) particle typing indicators

E) the channel number for reference

F) the center diameter for this channel of this probe. It is calculated by melting the maximum length.

G) the normalized density. It is calculated by computing the number of particles that would be detected by this channel size in a cubic meter of sample volume. Then for comparison with the other channels it is normalized by dividing it by the channel barwidth.

H) The liquid water content for this channel above are only repeated once for each channel of each probe. F, G, and H, cloud on the left, and the precip probe on the right.

2.3.3.2 Program KNOLL2D sample output (cont'd)

I) The set of calibrated VCO and VCO derived values. The basic VCO values are PRESSURE, DEWPOINT and TRUE AIRSPEED. HEIGHT is calculated from PRESSURE. TEMPERATURE and JW-LWC are both VCO's that are adjusted by airspeed. The C AIRSPEED is a calculated value given by PRESSURE, PRESSURE GRADIENT and TEMPERATURE.

J) The column under REJ is the number of particle used for computation in each channel when end rejection is applied. TOT is the total number counted in this channel Thus TOT-REJ= number of particle touching an end diode. There is one table for each probe.

K) Under each probe is a summary of various meteorological parameters. There is also a set for the TOTAL, this is the total of Cloud and Precip combined

1) M liquid water content
2) Z derived radar reflectivity
3) D0 median volume diameter
4) MK ratio of M to the square root of Z
5) SAMPLE (SEC)
   how many seconds elapsed collecting data for this average. This is the sum of the timing marks between all the particles that made up this average.

2.3.3.2 Program KNOLL2D sample output (cont'd)

There are five different ways of categorizing two dimensional particles; maximum length, horizontal feret projection, area, average projection ratio, and equivalent circle ration. The relationships between these categories is illustrated by KNOLL2D. There are five pages of distribution matrices, two per page, one for the cloud probe and one for precip (see figures 2.45-2.49. They demonstrate the relations between any two of these categories. These matrices are given once per pass and are therefore pass totals. References are given to figure 2.45.

A) The pass that generated this data

B) Sampling start and stop times

C) x axis parameter

D) Probe

E) Particle type used

F) Total number of sampling seconds (see K-5 in figure 2.44)

G) Totals of this row and which "channels" were used in these totals, values are sums of number density

H) y axis parameter

2.3.3.2 Program KNOLL2D sample output (cont'd)

I) Number density of all particles fitting in this x,y intercept is given in scientific notation, i.e. uv + z = uv.x 10^z. The "+" sign can take on the following

values and meanings:

+ positive exponent
* positive exponent and only one particle made up this entry
- negative exponent
_ (underline) negative exponent and only one particle made up this entry

*J) Size limits of this row, i.e. channel 01 has those particles whose maximum length is one or two diodes long

*K) same as J for the columns

L) same as G for the columns

* for maximum length, horizontal feret projection, and area these limits are number of diodes.
  for the ratios they are non-dimensional numbers

The last part of a KNOLL2D printout is a comparison of LWC, Z and other parameters for a complete pass, calculated by different methods. The method used for the first section was maximum length. Thus the first of these three comparisons is also calculated by maximum length, the second by horizontal Feret projection, the third and last by area. The

2.3.3.2 Program KNOLL2D sample output (cont'd)

output is shown in figures 2.50 and 2.52 and is identical in format to the first section figure 2.44. The difference between these outputs is that these pass averages are centered one per page and have the plot type descriptor above it.

```
**********************************************************************************************************

2 SECOND INTERVAL  START 15:37:28        ---FLIGHT INFORMATION---         PARTICLE  TYPES
                   STOP  15:37:29        - E77-23     22 MAR 77 -         CL: RAIN
                                         ------------------------         PP: RAIN

PMS-2D PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM EQUIVALENT MELTED DIAMETER)
                                                                                              //// TOTAL  COUNTS ////
    /////C L O U D  P R O B E/////     ////P R E C I P  P R O B E////                            CLOUD       PRECIP
 CH  **EQMD**  *NO-DENS*  ** LWC **    **EQMD**  *NO-DENS*  ** LWC **                           REJ  TOT    REJ  TOT
  1    58.0    0.          0.           464.3    1.277E+01  2.633E-04   HEIGHT      (METERS) 9031.57   0    0      2    2
  2   107.2    0.          0.           857.8    9.526E+00  1.245E-03   PRESSURE      (MB-K)  305.81   0    0      6    6
  3   156.9    0.          0.          1255.4    4.537E+00  1.871E-03   TEMPERATURE  (DEG C)  -42.61   0    0      3    3
  4   206.8    0.          0.          1654.1    4.527E+00  4.251E-03   DEWPOINT     (DEG C)  -28.64   0    0      3    3
  5   256.7    0.          0.          2053.4    1.508E+00  2.735E-03   C AIR SPEED  (M/SEC)  131.95   0    0      1    1
  6   305.6    0.          0.          2452.9    6.028E+00  1.551E-02   T AIR SPEED  (M/SEC)  127.44   0    0      4    4
  7   356.6    0.          0.          2852.6    3.013E+00  1.454E-02   JW-LWC     (GM/M**3)    -.01   0    0      2    2
  8   406.5    0.          0.          3252.3    1.506E+00  1.355E-02                                  0    0      1    1
  9   456.5    0.          0.          3652.1    6.024E+00  6.143E-02                                  0    0      4    4
 10   506.5    0.          0.          4052.0    0.         0.                                         0    0      0    0
 11   556.5    0.          0.          4451.9    0.         0.                                         0    0      0    0
 12   606.5    0.          0.          4851.8    1.506E+00  3.601E-02                                  0    0      1    1
 13   656.5    0.          0.          5251.7    0.         0.                                         0    0      0    0
 14   706.5    0.          0.          5651.7    1.505E+00  5.691E-02                                  0    0      1    1
 15   756.5    0.          0.          6051.6    0.         0.                                         0    0      0    0
                                                                        T O T A L
 M (GM/M**3)       0.                            2.088E-01              2.086E-01
 Z (MM**6/M**3)    0.                            3.517E+04              3.517E+04
 DO (MICRONS)      0.                            3.777E+03              3.776E+03
 MK (M/Z**.5)      0.                            1.114E-03              1.112E-03
 SAMPLE(SEC)          0.000                        7.862
**********************************************************************************************************

4 SECOND INTERVAL  START 15:37:45        ---FLIGHT INFORMATION---         PARTICLE  TYPES
                   STOP  15:37:48        - E77-23     22 MAR 77 -         CL: RAIN
                                         ------------------------         PP: RAIN

PMS-2D PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM EQUIVALENT MELTED DIAMETER)
                                                                                              //// TOTAL  COUNTS ////
    /////C L O U D  P R O B E/////     ////P R E C I P  P R O B E////                            CLOUD       PRECIP
 CH  **EQMD**  *NO-DENS*  ** LWC **    **EQMD**  *NO-DENS*  ** LWC **                           REJ  TOT    REJ  TOT
  1    58.0   2.719E+05  1.369E-03      464.3    1.391E+01  2.565E-04   HEIGHT      (METERS) 9033.77 110  122      5    5
  2   107.2   1.759E+05  5.621E-03      857.8    4.152E+00  5.427E-04   PRESSURE      (MB-K)  305.71 280  337      6    6
  3   156.9   6.042E+04  6.084E-03     1255.4    6.591E+00  2.713E-03   TEMPERATURE  (DEG C)  -42.69 231  244     10   10
  4   206.8   4.843E+04  1.118E-02     1654.1    2.631E+00  2.435E-03   DEWPOINT     (DEG C)  -25.27 154  187      4    4
  5   256.7   2.115E+04  9.350E-03     2053.4    6.571E-01  1.190E-03   C AIR SPEED  (M/SEC)  131.44  67   75      1    1
  6   306.6   5.474E+03  4.127E-03     2452.9    1.370E+00  6.314E-03   T AIR SPEED  (M/SEC)  126.93  15   20      3    3
  7   356.6   1.399E+03  1.660E-03     2852.6    1.313E+00  6.372E-03   JW-LWC     (GM/M**3)    -.01   4    4      2    2
  8   406.5   0.         0.            3251.3    6.565E-01  4.727E-03                                  0    0      1    1
  9   456.5   0.         0.            3652.1    6.564E-01  6.594E-03                                  0    0      1    1
 10   506.5   0.         0.            4052.0    6.563E-01  9.142E-03                                  0    0      1    1
 11   556.5   0.         0.            4451.9    6.563E-01  1.212E-02                                  0    0      1    1
 12   606.5   0.         0.            4851.8    6.562E-01  1.553E-02                                  0    0      1    1
 13   656.5   0.         0.            5251.7    6.562E-01  1.930E-02                                  0    0      1    1
 14   706.5   0.         0.            565                                                           0    0      0    0
 15   756.5   0.         0.            60                                                            0    0      2    2
                                                                        T O T A L
 M (GM/M**3)       3.978E-02                     1.489E-01              1.880E-01
 Z (MM**6/M**3)    9.232E-01                     3.935E+04              3.936E+04
 DO (MICRONS)      2.114E+02                     5.180E+03              4.703E+03
 MK (M/Z**.5)      4.105E-02                     7.535E-04              9.475E-04
 SAMPLE(SEC)         13.353                        18.096
```

Figure 2.44: KNOLL2D sample data

```
A  PASS  1  DISTRIBUTION MATRICES
B    START 15:30:00
     STOP  15:37:49

C  HORIZONTAL FERET PROJECTION     D CLOUD PROBE  E RAIN          F 418.979 SECOND SAMPLE     TOTAL  G
   *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                01-16
H
     01 34+3                                                              ( 1 -  2)  J           34+3
M    02 99+2 40+2                                                         ( 3 -  4)              14+3
A    03 20+1 17+2 13+2                                                    ( 5 -  6)              32+2
X    04 94-1 34+0 13+2 72+1                     I                         ( 7 -  8)              21+2
I    05 41-1 57-1 47+0 92+1 25+1                                          ( 9 - 10)              12+2
M    06 12-1 44-2 42-1 39+0 45+1 50+0                                     (11 - 12)              55+1
U    07 41-2 13-1 94-2 71-1 27+1 24+1 26+0                                (13 - 14)              30+1
M    08           14-1 15-1 83-1 27+0 92+0 99-1                           (15 - 16)              14+1
     09      44-2      51-2 17_1 37-1 11+0 31+0 87-2                      (17 - 18)              49+0
L    10                51-2 56-2 61_2 34-1 64_1 14+0 10-1                 (19 - 20)              28+0
F    11                     56-2 61-2 14-1 23_1 87_1 51-1                 (21 - 22)              19+0
N    12                          61-2 63-2      87-2 10_1 24-1            (23 - 24)              56-1
G    13                                                   12-1            (25 - 26)              12-1
T    14                                         87-2 10-1                 (27 - 28)              19-1
H    15                                                        20-1       (29 - 30)              20-1
     16                                                                   (31 - 32)
K     (  1)(  3)(  5)(  7)(  9)( 11)( 13)( 15)( 17)( 19)( 21)( 23)( 25)( 27)( 29)( 31)
      (  2)(  4)(  6)(  8)( 10)( 12)( 14)( 16)( 18)( 20)( 22)( 24)( 26)( 28)( 30)( 32)

  TOTAL 4.43E+04  2.72E+03  7.41E+02  1.34E+02  2.57E+01  7.67E+00  2.04E+00  0.
L 01-15      5.71E+03  1.69E+03  3.19E+02  5.19E+01  8.15E+00  0.        0.        0.

   HORIZONTAL FERET PROJECTION          PRECIP PROBE    RAIN           460.976 SECOND SAMPLE      TOTAL
   *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                01-16

     01 58-1                                                              ( 1 -  2)              56-1
M    02 34-1                                                              ( 3 -  4)              34-1
A    03 27-1                                                              ( 5 -  6)              27-1
X    04 18-1                                                              ( 7 -  8)              18-1
I    05 13-1                                                              ( 9 - 10)              13-1
M    06 96-2                                                              (11 - 12)              96-2
U    07 73-2                                                              (13 - 14)              73-2
M    08 69-2                                                              (15 - 16)              69-2
     09 67-2                                                              (17 - 18)              67-2
L    10 54-2                                                              (19 - 20)              54-2
F    11 43-2                                                              (21 - 22)              43-2
N    12 47-2                                                              (23 - 24)              47-2
G    13 37-2                                                              (25 - 26)              37-2
T    14 34-2                                                              (27 - 28)              34-2
H    15 39-2                                                              (29 - 30)              33-2
     16 36-1                                                              (31 - 32)              36-1
      (  1)(  3)(  5)(  7)(  9)( 11)( 13)( 15)( 17)( 19)( 21)( 23)( 25)( 27)( 29)( 31)
      (  2)(  4)(  6)(  8)( 10)( 12)( 14

  TOTAL 2.42E+01  0.        0.        0.        0.        0.        0.        0.
  01-16      0.        0.        0.        0.        0.        0.        0.        0.
```

Figure 2.45: KNOLL2D sample data

```
                        PASS  1  DISTRIBUTION MATRICES
         START 16:30:00
          STOP 16:37:49

         AREA                                    CLOUD PROBE      RAIN                          416.979 SECOND SAMPLE       TOTAL
          *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                                  01-16

      01 34+3                                                                                  ( 1 -  2)                   34+3
  M   02 11+3 31+2                                                                             ( 3 -  4)                   14+3
  A   03 16+1 15+2 15+2 14+1                                                                   ( 5 -  6)                   32+2
  Y   04 29-1 41+0 51+1 12+2 34+1                                                              ( 7 -  8)                   21+2
  I   05      10+0 17+0 12+1 82+1 26+1 15-1                                                    ( 9 - 10)                   12+2
  M   06      11-1 29-1 69-1 74+0 30+1 16+1 61-1                                               (11 - 12)                   55+1
  U   07           25-1 27-1 47-1 44+0 15+1 92+0 43-1                                          (13 - 14)                   30+1
  M   08                     17-1 11-1 12+0 63+0 51+0 11+0 68-2                                (15 - 16)                   14+1
      09                     44-2           78-1 12+0 21+0 11+0                                (17 - 18)                   49+0
  L   10                          16-1      87-2 72-1 63-1 91-1 39-1                           (19 - 20)                   23+0
  E   11                                    10-1 56-2 36-1 23-1 70-1 41-1                      (21 - 22)                   19+0
  N   12                                              61-2      41-1 87-2                      (23 - 24)                   56-1
  G   13                                                             12-1                      (25 - 26)                   12-1
  T   14                                                             19-1                      (27 - 28)                   19-1
  H   15                                                                            20-1       (29 - 30)                   20-1
      16                                                                                       (31 - 32)
        (   1)(   5)(  10)(  17)(  26)(  40)(  55)(  71)(  91)( 111)( 131)( 161)( 191)( 221)( 251)( 281)
        (   4)(   9)(  16)(  25)(  39)(  54)(  70)(  90)( 110)( 130)( 160)( 190)( 220)( 250)( 280)(****)

 TOTAL 4.57E+04  2.03E+03  1.24E+03  3.18E+02  7.59E+01  2.36E+01  8.13E+00  0.
 1-15      4.60E+03  1.45E+03  6.10E+02  1.67E+02  4.28E+01  1.51E+01  0.            2.04E+00

         AREA                                    PRECIP PROBE     RAIN                          460.976 SECOND SAMPLE       TOTAL
          *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                                  01-16

      01 58-1                                                                                  ( 1 -  2)                   58-1
  M   02 34-1                                                                                  ( 3 -  4)                   34-1
  A   03 15-1 11-1                                                                             ( 5 -  6)                   27-1
  Y   04      18-1                                                                             ( 7 -  8)                   18-1
  I   05      13-1      11-3                                                                   ( 9 - 10)                   13-1
  M   06           95-2                                                                        (11 - 12)                   96-2
  U   07           73-2                                                                        (13 - 14)                   73-2
  M   08           69-2                                                                        (15 - 16)                   69-2
      09           79-2 27-2                                                                   (17 - 18)                   67-2
  L   10                54-2                                                                   (19 - 20)                   54-2
  E   11                42-2 11-3                                                              (21 - 22)                   43-2
  N   12                45-2 11-3                                                              (23 - 24)                   47-2
  G   13                37-2                                                                   (25 - 26)                   37-2
  T   14                     34-2                                                              (27 - 28)                   34-2
  H   15                     39-2                                                              (29 - 30)                   39-2
      16                     93-2 10-1 50-2 42-2 31-2 12-2 13-2 85-3 32-3 21-3      11-3       (31 - 32)                   36-1
        (   1)(   5)(  10)(  17)(  26)(  40)(  55)(  71)(  91)( 111)( 131)( 161)( 191)( 221)( 251)( 281)
        (   4)(   9)(  16)(  25)(  39)(  54)(                                                )(****)

 TOTAL 1.08E+01  2.77E+00  1.68E+00  4.97E-01  3.07E-01  1.27E-01  3.17E-02  0.
 01-15     4.27E+00  2.07E+00  1.00E+00  4.23E-01  1.16E-01  8.46E-02  2.11E-02    1.06E-02
```

Figure 2.46: KNOLL2D sample data

```
                         PASS  1  DISTRIBUTION MATRICES
      START 15:30:00
       STOP 16:37:49

       AVERAGE PROJECTION RATIO            CLOUD PROBE      RAIN                      416.979 SECOND SAMPLE      TOTAL
       *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                         01-15

     01 34+3                                                                         ( 1 -  2)              34+3
  M  02 14+3 55+0 80+0 64-1                                                          ( 3 -  4)              14+3
  A  03 2?+2 44+1 21+1 46+0 40-1                                                     ( 5 -  6)              32+2
  X  04 13+? 54+1 17+1 66+0 17+0        51_2                                         ( 7 -  8)              21+2
  I  05 83+1 25+1 96+? 35+0 15+0                   56_2                              ( 9 - 10)              12+2
  M  06 33+1 15+1 44+0 15+0 74-1              61_2 11-1                              (11 - 12)              55+1
  U  07 15+1 91+0 36+0 75-1 81-1 61_2 61_2                                           (13 - 14)              30+1
  M  08 62+0 51+0 17+0 91-1 14-1                                                     (15 - 16)              14+1
     09 2?+0 1?+0 75-1 21-1 76_2                                                     (17 - 18)              49+0
  L  10 46-1 12+0 90-1 23-1 10_1        87_2                                         (19 - 20)              28+0
  E  11 55-1 44-1 49-1 38-1                                                          (21 - 22)              19+0
  N  12 22-1 ?5-1                                                                    (23 - 24)              56-1
  G  13           12_1                                                               (25 - 26)              12-1
  T  14      87_2      10_1                                                          (27 - 28)              19-1
  H  15                20_1                                                          (29 - 30)              20-1
     16                                                                              (31 - 32)
       (1.0)(1.1)(1.2)(1.3)(1.4)(1.5)(1.6)(1.7)(1.8)(1.9)(2.0)(2.1)(2.2)(2.3)(2.4)(2.5)
       (1.1)(1.2)(1.3)(1.4)(1.5)(1.6)(1.7)(1.8)(1.9)(2.0)(2.1)(2.2)(2.3)(2.4)(2.5)(2.6)

TOTAL 5.?0E+02  1.19E+02  1.86E+01  1.48E+00  1.11E+00  0.       0.       0.
0?-15      ?.28E+02  4.31E+01  6.11E-01  6.11E-01  0.       0.       0.       0.

       AVERAGE PROJECTION RATIO           PRECIP PROBE      RAIN                      460.976 SECOND SAMPLE      TOTAL
       *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                         01-15

     01 58-1                                                                         ( 1 -  2)              58-1
  M  02 34-1                                                                         ( 3 -  4)              34-1
  A  03 27-1                                                                         ( 5 -  6)              27-1
  X  04 18-1                                                                         ( 7 -  8)              18-1
  I  05 1?-1                                                                         ( 9 - 10)              13-1
  M  06 96-2                                                                         (11 - 12)              96-2
  U  07 7?-2                                                                         (13 - 14)              73-2
  M  08 69-2                                                                         (15 - 16)              69-2
     09 67-2                                                                         (17 - 18)              67-2
  L  10 54-2                                                                         (19 - 20)              54-2
  E  11 4?-2                                                                         (21 - 22)              43-2
  N  12 4?-2                                                                         (23 - 24)              47-2
  G  13 ?7-2                                                                         (25 - 26)              37-2
  T  14 34-2                                                                         (27 - 28)              34-2
  H  15 39-2                                                                         (29 - 30)              39-2
     16 34-1      ?4-?       21-3             ?1 3                                   (31 - 32)              36-1
       (1.0)(1.1)(1.2)(1.3)(1.4)(1.5)
       (1.1)(1.2)(1.3)(1.4)(1.5)(1.6)

TOTAL ?.58E+0?  0.       0.       0.       0.       0.       0.       0.
06-15      0.       0.       0.       0.       0.       0.       0.       0.
```

Figure 2.47: KNOLL2D sample data

```
PASS 1 DISTRIBUTION MATRICES
START 16:30:00
STOP 16:37:49

EQUIVALENT CIRCLE RATIO             CLOUD PROBE    RAIN                         416.979 SECOND SAMPLE     TOTAL
 *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                          01-15

    01 34+3                                                                       ( 1 -  2)          34+3
M   02 75+2 53+2 11+2 67+0 21-1                                                   ( 3 -  4)          14+3
A   03 40+1 17+2 86+1 26+1 14+0 15-1                                              ( 5 -  6)          32+2
X   04 64+0 92+1 74+1 30+1 48+0 32-1                                              ( 7 -  8)          21+2
I   05 19+0 56+1 49+1 13+1 76+0 60-1      44_2                                    ( 9 - 10)          12+2
M   06 11-1 13+1 26+1 67+0 19+0 31-1 47_2                                         (11 - 12)          55+1
U   07      67+0 16+1 53+0 94-1 48-1 13-1                                         (13 - 14)          70+1
M   08      25+0 78+0 29+0 75-1 11-1      47_2                                    (15 - 16)          14+1
    09      75-1 27+0 98-1 55-1                                                   (17 - 18)          49+0
L   10      14-1 73-1 12+0 61-1 19-1                                              (19 - 20)          28+0
E   11           84-1 54-1 17-1 21-1 10_1                                         (21 - 22)          19+0
N   12           97_2 48-1                                                        (23 - 24)          56-1
G   13                12_1                                                        (25 - 26)          12-1
T   14                87_2           10_1                                         (27 - 28)          13-1
H   15                     20_1                                                   (29 - 30)          20-1
    16                                                                            (31 - 32)
 (1.0)(1.2)(1.4)(1.6)(1.8)(2.0)(2.2)(2.4)(2.6)(2.8)(3.0)(3.2)(3.4)(3.6)(3.8)(4.0)
 (1.2)(1.4)(1.6)(1.8)(2.0)(2.2)(2.4)(2.6)(2.8)(3.0)(3.2)(3.4)(3.6)(3.8)(4.0)(4.2)

TOTAL 1.11E+00  5.40E+02  5.14E+01  3.80E+00  0.       0.       0.       0.
6-15       2.94E+02  1.85E+02  1.30E+01  4.70E-01  0.       0.       0.       0.

EQUIVALENT CIRCLE RATIO             PRECIP PROBE    RAIN                        460.976 SECOND SAMPLE     TOTAL
 *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                          01-15

    01 58-1                                                                       ( 1 -  2)          56-1
M   02 19-1 16-1 11_3                                                             ( 3 -  4)          34-1
A   03 21-3      26-1                                                             ( 5 -  6)          27-1
X   04                18-1                                                        ( 7 -  8)          18-1
I   05           11_3 75-2 54-2                                                   ( 9 - 10)          13-1
M   06                     53-2 43-2                                              (11 - 12)          96-2
U   07                          73-2                                              (13 - 14)          73-2
M   08                               69-2                                         (15 - 16)          69-2
    09                               49-2 26-2                                    (17 - 18)          57-2
L   10                                    54-2                                    (19 - 20)          54-2
E   11                               11_3      42-2                               (21 - 22)          43-2
N   12                               11_3      25-2 20-2                          (23 - 24)          47-2
G   13                                              37-2                          (25 - 26)          37-2
T   14                                              19-2 15-2                     (27 - 28)          34-2
H   15                                                   39-2                     (29 - 30)          39-2
    16                                                                            (31 - 32)          17-1
 (1.0)(1.2)(1.4)(1.6)(1.8)(2.0)(2.2)(2.
 (1.2)(1.4)(1.6)(1.8)(2.0)(2.2)(2.4)(2.6)

TOTAL 0.      0.      5.29E-01  1.11E+00  6.77E-01  5.39E-01  0.       0.
16-15      0.      0.      1.16E+00  8.03E-01  7.51E-01  0.       0.       0.
```

Figure 2.48: KNOLL2D sample data

```
                              PASS  1  DISTRIBUTION MATRICES
     START 16:30:00
      STOP 15:37:49

        EQUIVALENT CIRCLE RATIO             CLOUD PROBE     RAIN                           416.979 SECOND SAMPLE     TOTAL
           *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                            01-15

        01 11-1 29+1 23+1 20+0 17-1 17-1                                                   (1.00 - 1.10)       59+1
   A    02      13+0 24+1 74+0 45-1 61_2 47_2                                              (1.10 - 1.20)       33+1
   V    03           25+0 70+0 17+0 26-1      47_2                                         (1.20 - 1.30)       12+1
   E    04           14-1 22+0 15+0 26-1 20-1                                              (1.30 - 1.40)       43+0
        05                20-1 12+0 37-1 13-1                                              (1.40 - 1.50)       19+0
   P    06                          61_2                                                   (1.50 - 1.60)       61-2
   R    07                     87_2 61_2                                                   (1.60 - 1.70)       15-1
   O    08                     61_2                                                        (1.70 - 1.80)       61-2
   J    09                     56_2 56_2                                                   (1.80 - 1.90)       11-1
        10                                                                                 (1.90 - 2.00)
   P    11                                                                                 (2.00 - 2.10)
   A    12                                                                                 (2.10 - 2.20)
   T    13                                                                                 (2.20 - 2.30)
   I    14                                                                                 (2.30 - 2.40)
   O    15                                                                                 (2.40 - 2.50)
        15                                                                                 (2.50 - 2.60)
          (1.0)(1.2)(1.4)(1.6)(1.8)(2.0)(2.2)(2.4)(2.6)(2.8)(3.0)(3.2)(3.4)(3.6)(3.8)(4.0)
          (1.2)(1.4)(1.6)(1.8)(2.0)(2.2)(2.4)(2.6)(2.8)(3.0)(3.2)(3.4)(3.6)(3.8)(4.0)(4.2)

TOTAL 1.11E+00  5.40E+02  5.14E+01  3.80E+00  0.        0.        0.        0.
01-15      2.94E+02  1.99E+02  1.30E+01  4.70E-01  0.        0.        0.        0.

        EQUIVALENT CIRCLE RATIO             PRECIP PROBE    RAIN                           460.976 SECOND SAMPLE     TOTAL
           *01* *02* *03* *04* *05* *06* *07* *08* *09* *10* *11* *12* *13* *14* *15* *16*                            01-15

        01                     57-2 12-1 11-1 80-2 68-2 78-2 64-2 44-2 34-2 53-2 26-2 17-1 (1.00 - 1.10)       73-1
   A    02                                                                                 (1.10 - 1.20)
   V    03                                              11_3      11_3      11_3      42-3 (1.20 - 1.30)       32-3
   E    04                                                                                 (1.30 - 1.40)
        05                                                                            21-3 (1.40 - 1.50)
   P    06                                                                                 (1.50 - 1.60)
   R    07                                                                                 (1.60 - 1.70)
   O    08                                                                            11_3 (1.70 - 1.80)
   J    09                                                                                 (1.80 - 1.90)
        10                                                                                 (1.90 - 2.00)
   P    11                                                                                 (2.00 - 2.10)
   A    12                                                                                 (2.10 - 2.20)
   T    13                                                                                 (2.20 - 2.30)
   I    14                                                                                 (2.30 - 2.40)
   O    15                                                                                 (2.40 - 2.50)
        16                                                                                 (2.50 - 2.60)
          (1.0)(1.2)(1.4)(1.6)(1.8)(2.0)(                                                ))
          (1.2)(1.4)(1.6)(1.8)(2.0)(2.2)(                                                2))

TOTAL 0.        0.        5.29E-01  1.11E+00  6.77E-01  6.45E-01  3.38E-01  2.64E-01
01-15      0.        0.        1.16E+00  8.03E-01  7.93E-01  4.59E-01  5.39E-01  1.82E+00
```

Figure 2.49: KNOLL2D sample data

```
DISTRIBUTION BY  MAXIMUM LENGTH

                                                ---FLIGHT INFORMATION---            PARTICLE  TYPES
470 SECOND PASS      START 15:30:00              - 77-23    22 MAR 77  -            CL: RAIN
                      STOP 15:37:49              ------------------------            PR: RAIN

PMS-2D PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM EQUIVALENT MELTED DIAMETER)
                                                                                                        //// TOTAL--COUNTS ////
     /////C L O U D   P R O B E/////      ////P R E C I P   P R O B E////                                  CLOUD       PRECIP
 CH  **EQMD**  *NO-DENS*  ** LWC **      **EQMD**  *NO-DENS*  ** LWC **                                 REJ   TOT    REJ   TOT
  1    58.0    6.955E+05  3.501E-03        46.3    1.400E+01  3.251E-04   HEIGHT       (METERS) 8957.23   8605  9130   132   132
  2   107.2    2.699E+05  8.963E-03       857.8    8.673E+00  1.133E-03   PRESSURE       (MB-K)  307.84  13707 15969   311   311
  3   156.9    6.522E+04  6.568E-03      1255.4    6.691E+00  2.763E-03   TEMPERATURE   (DEG C)  -41.83   6697  6123   252   252
  4   206.9    4.151E+04  9.605E-03      1654.1    4.610E+00  4.359E-03   DEWPOINT      (DEG C)  -33.99   4327  5433   174   174
  5   256.7    2.453E+04  1.091E-02      2053.4    3.256E+00  5.935E-03   C AIR SPEED   (M/SEC)  123.05   2393  3098   123   123
  6   306.6    1.092E+04  8.235E-03      2452.3    2.408E+00  7.434E-03   T AIR SPEED   (M/SEC)  123.13    993  1361    91    91
  7   356.6    5.977E+03  7.089E-03      2852.6    1.825E+00  8.365E-03   JW-LWC      (GM/M**3)    -.01    493   678    69    69
  8   406.5    2.822E+03  4.961E-03      3252.3    1.719E+00  1.238E-02                                    215   294    65    65
  9   456.5    9.859E+02  2.457E-03      3652.1    1.666E+00  1.593E-02                                     63    94    63    63
 10   506.5    5.692E+02  1.976E-03      4052.0    1.348E+00  1.873E-02                                     36    47    51    51
 11   556.5    3.729E+02  1.681E-03      4451.9    1.084E+00  2.073E-02                                     22    31    41    41
 12   606.5    1.125E+02  6.570E-04      4851.9    1.163E+00  2.752E-02                                      6    10    44    44
 13   656.5    2.444E+01  1.810E-04      5251.7    9.252E-01  2.855E-02                                      1     3    35    35
 14   706.5    7.793E+01  3.491E-04      5651.7    8.459E-01  3.198E-02                                      2     4    32    32
 15   756.5    4.073E+01  4.616E-04      6051.6    9.790E-01  4.533E-02                                      1     1    37    37
                                                                          T O T A L
 W (GM/M**3)        6.755E-02                      2.322E-01              2.961E-01
 Z (MM**6/M**3)     4.754E+00                      5.297E+04              5.298E+04
 DO(MICRONS)        2.552E+02                      4.899E+03              4.294E+03
 MV(M/7**.5)        3.095E-02                      1.009E-03              1.296E-03
 SAMPLE(SEC)        418.979                        460.976
****************************************************************************************************************************
```

Figure 2.50: KNOLL2D sample data

DISTRIBUTION BY HORIZONTAL FERET PROJECTION

470 SECOND PASS   START 15:30:00   ---FLIGHT INFORMATION---   PARTICLE TYPES
STOP 15:37:49   F77-23   22 MAR 77   CL: RAIN
PR: RAIN

PMS-2D PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM EQUIVALENT MELTED DIAMETER)

	//////CLOUD PROBE//////			////PRECIP PROBE////			//// TOTAL COUNTS //// CLOUD		PRECIP	
CH	**EQMD**	*NO-DENS*	** LWC **	**EQMD**	*NO-DENS*	** LWC **	REJ	TOT	REJ	TOT
1	37.5	8.859E+05	1.224E-03	300.0	5.159E+01	2.918E-04	19992	21128	1856	1856
2	87.5	1.141E+05	2.002E-03	700.0	0.	0.	7495	9791	0	0
3	137.5	5.433E+04	3.698E-03	1100.0	0.	0.	5557	6565	0	0
4	187.5	3.378E+04	5.829E-03	1500.0	0.	0.	3317	4319	0	0
5	237.5	1.492E+04	5.137E-03	1900.0	0.	0.	1334	1715	0	0
6	287.5	6.379E+03	3.968E-03	2300.0	0.	0.	522	667	0	0
7	337.5	2.698E+03	2.706E-03	2700.0	0.	0.	193	255	0	0
8	387.5	1.039E+03	1.582E-03	3100.0	0.	0.	53	78	0	0
9	437.5	5.062E+02	1.110E-03	3500.0	0.	0.	23	41	0	0
10	487.5	1.629E+02	4.942E-04	3900.0	0.	0.	8	13	0	0
11	537.5	7.332E+01	2.981E-04	4300.0	0.	0.	3	4	0	0
12	587.5	0.	0.	4700.0	0.	0.	0	1	0	0
13	637.5	4.073E+01	2.763E-04	5100.0	0.	0.	1	1	0	0
14	687.5	0.	0.	5500.0	0.	0.	0	1	0	0
15	737.5	0.	0.	5900.0	0.	0.	0	0	0	0

HEIGHT	(METERS)	6967.23
PRESSURE	(MB-K)	307.84
TEMPERATURE	(DEG C)	-41.83
DEWPOINT	(DEG C)	-30.99
C AIR SPEED	(M/SEC)	128.03
T AIR SPEED	(M/SEC)	123.13
JW-LWC	(GM/M**3)	-.01

	CLOUD PROBE	PRECIP PROBE	T O T A L
M (GM/M**3)	2.838E-02	2.918E-04	2.781E-02
Z (MM**6/M**3)	1.294E+00	1.504E-02	1.069E+00
DO(MICRONS)	2.263E+02	3.000E+02	2.236E+02
MK(M/7**.5)	2.495E-02	2.379E-03	2.690E-02
SAMPLE(SEC)	418.979	460.976	

Figure 2.51: KNOLL2D sample data

DISTRIBUTION BY AREA

470 SECOND PASS START 16:30:00 STOP 16:37:49

---FLIGHT INFORMATION--- E77-23 22 MAR 77

PARTICLE TYPES
CL: RAIN
PP: RAIN

PMS-2D PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM EQUIVALENT MELTED DIAMETER)

	//////CLOUD PROBE//////			////PRECIP PROBE////						//// TOTAL COUNTS //// CLOUD		PRECIP	
CH	**EQMD**	*NO-DENS*	** LWC **	**EQMD**	*NO-DENS*	** LWC **				REJ	TOT	REJ	TOT
1	54.5	1.814E+06	3.825E-03	435.9	5.409E+01	4.672E-04	HEIGHT	(METERS)	8987.23	19694	21591	587	587
2	91.[illegible]	2.443E+05	1.294E-03	650.2	2.834E+01	6.149E-04	PRESSURE	(MB-K)	307.84	6124	7661	404	404
3	105.0	9.253E+04	1.265E-03	845.1	1.581E+01	8.848E-04	TEMPERATURE	(DEG C)	-41.83	4142	5155	262	262
4	133.[illegible]	5.638E+04	1.740E-03	1055.3	1.021E+01	1.277E-03	DEWPOINT	(DEG C)	-30.99	2956	3749	196	196
5	164.1	3.751E+04	2.878E-03	1312.8	2.830E+00	8.603E-04	C AIR SPEED	(M/SEC)	126.03	2470	3146	153	155
6	197.8	2.651E+04	2.473E-03	1587.4	0.	0.	T AIR SPEED	(M/SEC)	123.13	1122	1531	95	95
7	228.3	1.157E+04	1.983E-03	1826.5	0.	0.	JW-LWC	(GM/M**3)	-.01	548	745	47	47
8	259.1	5.438E+03	1.520E-03	2077.1	0.	0.				256	379	40	40
9	289.7	2.764E+03	9.660E-04	2317.8	0.	0.				113	156	29	29
10	317.4	1.707E+03	7.160E-04	2535.8	0.	0.				60	73	11	11
11	348.6	6.766E+02	5.224E-04	2788.5	0.	0.				32	41	12	12
12	383.0	4.760E+02	4.437E-04	3063.7	0.	0.				17	21	8	8
13	414.5	2.777E+02	3.072E-04	3315.0	0.	0.				9	13	3	3
14	447.[illegible]	0.	0.	3553.3	0.	0.				0	3	2	2
15	471.3	0.	0.	3772.1	0.	0.				0	1	0	0

	Cloud	Precip	TOTAL
W (GM/M**3)	1.333E-02	4.137E-03	2.233E-02
Z (MM**6/M**3)	3.891E-01	8.141E+00	8.326E+00
D0 (MICRONS)	1.687E+02	9.578E+02	1.878E+02
MV (M/?**.5)	3.195E-02	1.449E-03	7.737E-03
SAMPLE(SEC)	418.973	460.976	

Figure 2.52: KNOLL2D sample data

2.3.4 Program COPKNE

COPKNE is a special utility program written during this contract period. It copies segments of several PMS-2D data tapes onto a single tape. In addition it has the ability to fix the recorded A/C time of each copied slow record. This is critical when non-consecutive data is copied and the clock is bad.

There are three times associated with each 2D slow record. The A/C clock; the elapsed second clock and the "record" time in elapsed seconds of the slow record. The "record" time of the record is taken from the elapsed second clock when the slow record is recorded, while the elapsed second time is the time at which the ten second buffer began. Thus, a nine second difference exists between the two. COPKNE has been written to key on any one of these three record times. When the A/C clock is bad the "record" time of the first slow record of the tape, must be input. The program will internally handle the nine second difference in elapsed time. In addition, before writing out this copied record, the buffer will be altered to contain the correct A/C time.

COPKNE operating instructions follow:

2.3.4 Program COPKNE operating instructions

COMMAND CARDS

```
DPSI,T300,NT2.                      ID#            IDNAME
ATTACH,LGO,COPKNEBIN,ID=GLASS,MR=1.
VSN,TAPE1=KNEXXX/NT.
VSN,TAPE2=OUTPUTTAPENUMBER/NT.
REQUEST,TAPE1,PE,L,NORING,NT,NR.
REQUEST,TAPE2,PE,L,RING,NT.
FILE(TAPE1,RT=U,BT=K,MRL=5576,MBL=5576,RB=1,BFS=560)
FILE(TAPE2,RT=U,BT=K,MRL=5576,MBL=5576,RB=1,BFS=560)
LGO.
7/8/9
```

DATA CARDS

```
CARD #1
CC   5      ICLOCK-1=A/C CLOCK
                   2=RECORDED PMS TIME ON FIRST SLOW RECORD
                   3=RECORD TIME OF FIRST SLOW RECORD
CC  10      IPOS   1=POSITION TAPE2 AT END OF PREVIOUSLY COPIED
                     DATA
CC  20-25          PMS ON TIME - THIS OPTION USED FOR ICLOCK=
                      2 or 3 (ALWAYS USE RECORD TIME OF FIRST
                      SLOW RECORD ON TAPE1 - NOTE THAT RECORD
                      TIME = RECORDED A/C TIME + 9 SECONDS)
CARDS 2-(N+1) -    N PASSES IN TIME INCREASING ORDER
CC   1-6           START TIME IN FORM HHMMSS
CC   8-13          STOP TIME IN FORM HHMMSS
6/7/8/9
```

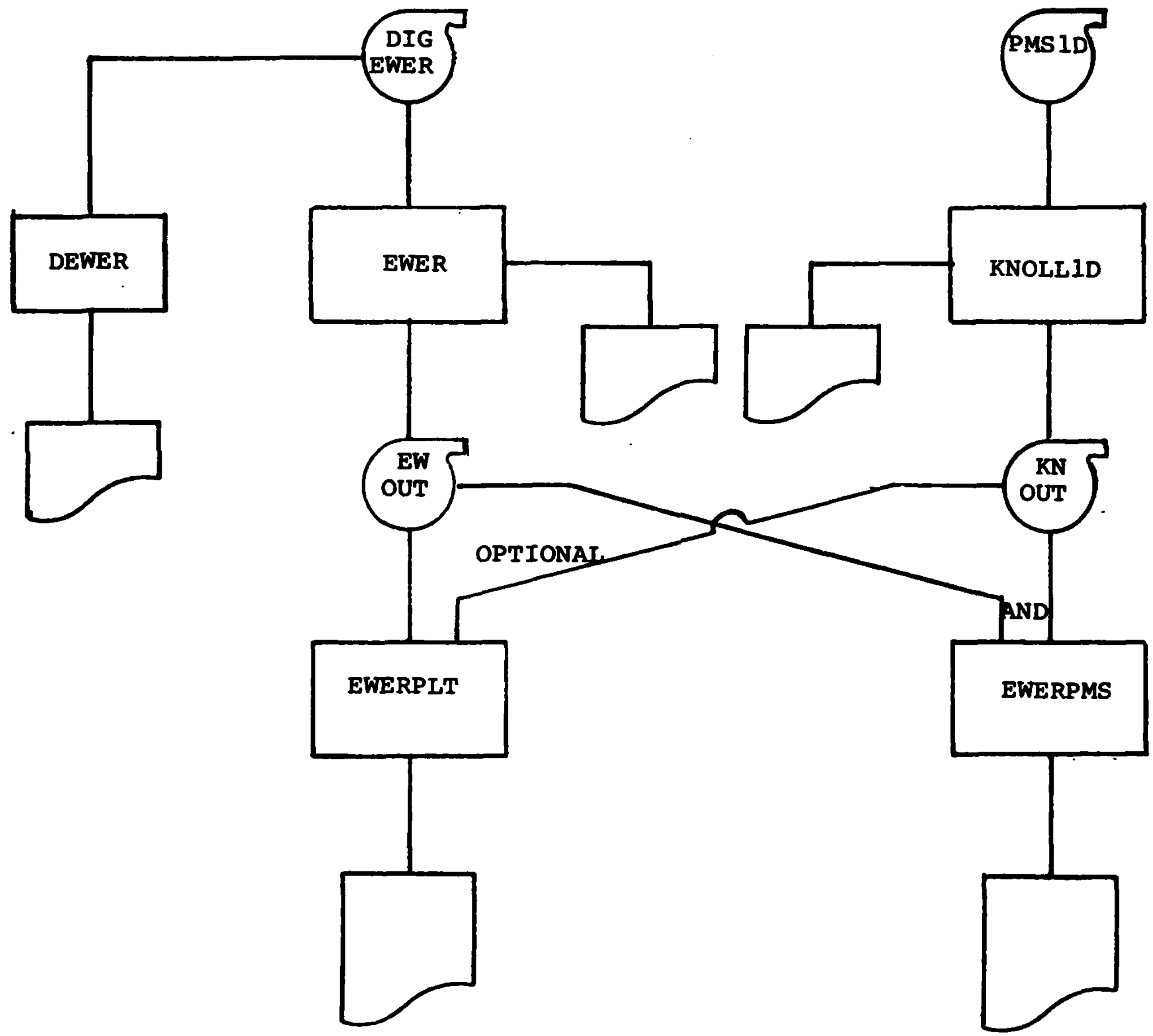
2.4 EWER analysis

As outlined in the following diagram EWER analysis requires step-by-step procedures to analyze the data. First the analog recorded tapes are processed at AFGL producing digital equivalents. Program DEWER can then be run to determine the status of the system and to show the data time intervals. Program EWER is run on those time intervals, producing a printed output as well as a plot tape for further analysis. Using the EWER plot tape program EWERPLT can be run to produce long pen plots of selected values. Optionally a KNOLL1D produced plot tape can be run with EWERPLT to produce comparison plots of EWER LWC and KNOLL1D LWC values.

Program EWERPMS requires both the EWER and KNOLL1D produced output tapes. This program produces plots of EWER versus KNOLL1D data, and shows the correlation of EWER and PMS LWC.

A detailed explanation of the individual programs can be found in the following sections.

Figure 2.53: EWER Analysis Program Flow



2.4.1 Program DEWER

DEWER is a utility program to verify the digitized data tape from analog EWER data. DEWER dumps the condensate and reference voltages for 3 detectors as well as the four VCO's associated with the device. (see section on EWER).

These values are in the form of raw counts and are dumped to the line printer. Visual analysis can then determine if major fluctuations exist.

2.4.1.1 Program DEWER c· ·ating instructions

DEWER OPERATING INSTRUCTIONS

```
LALEW,CM65000,T200,TP1.            ACCT #          NAME
VSN,TAPE1=EWERTP.   (DIGITIZED TAPE)
REQUEST,TAPE1,MT,L,NORING.
ATTACH,LGO,DEWERBIN,ID=GLASS,MR=1.
FILE(TAPE1,BT=E,RT=S,MBL=2040,MRL=2040,RB=1,FL=2040,BFS=206)
LDSET,PRESET=ZERO.
LGO.
6/7/8/9
```

2.4.1.2 DEWER sample output

8/21:16:61 FILE: 2 RECORD: 6 CH/FR: 13
NR: 240 TAPE NO: 1 SYSID: 316

MSEC	1	2	3	4	5	6	7	8	9	10	11	12	13
910	270	280	272	275	280	279	281	79	279	1893	-551	-181	-730
144	282	280	272	282	280	279	272	282	283	1894	-517	-182	-726
375	277	279	282	278	277	276	275	282	280	1894	-532	-182	-719
609	279	280	278	277	276	283	278	279	290	1893	-524	-175	-718
842	278	275	279	278	288	276	277	279	279	1893	-521	-184	-727
74	282	277	272	276	272	279	282	280	277	1893	-528	-184	-728
307	276	277	273	278	282	273	284	280	283	1894	-531	-184	-732
540	275	276	280	274	278	275	278	282	288	1894	-519	-180	-722
772	277	278	284	279	281	287	286	279	280	1893	-539	-174	-713
6	277	286	279	275	249	273	284	288	274	1893	-517	-184	-729
238	281	275	288	286	278	279	289	79	281	1894	-538	-179	-716
471	275	284	274	274	282	274	283	285	272	1894	-527	-187	-734
703	282	269	285	284	276	277	285	274	281	1893	-518	-179	-720
936	281	283	279	266	279	286	277	84	281	1894	-542	-181	-719
169	275	277	282	275	286	278	281	281	284	1894	-520	-183	-726
401	280	275	280	281	279	281	279	278	274	1894	-529	-183	-723
634	275	282	280	280	280	280	278	277	1894	-507	-177	-728	595
867	277	278	284	278	280	280	282	276	283	1893	-538	-174	-721
99	281	277	280	277	276	279	275	284	282	1894	-509	-179	-717
332	276	276	278	277	276	274	286	277	279	1893	-531	-179	-720
565	284	272	283	275	276	277	280	280	276	1893	-526	-177	-722
748	286	277	283	280	278	282	283	285	281	1893	-540	-181	-726
31	283	275	277	275	287	272	286	284	280	1893	-513	-180	-722
264	285	272	291	277	270	281	269	290	285	1893	-517	-176	-719
497	272	271	279	274	281	278	278	293	280	1894	-529	-184	-722
730	277	284	286	266	282	280	275	282	280	1893	-530	-182	-731
963	276	268	280	280	279	277	277	278	284	1894	-534	-178	-719
196	281	280	285	273	275	274	278	284	281	1894	-524	-178	-724
428	277	278	277	279	282	281	277	281	279	1894	-526	-179	-720
662	278	277	279	275	284	275	280	279	281	1894	-523	-175	-718
895	272	277	279	276	282	273	281	280	279	1894	-512	-178	-720
127	275	272	284	273	277	278	278	281	276	1894	-526	-179	-725
361	279	276	275	281	282	277	282	281	277	1894	-520	-182	-729
592	271	280	279	279	281	281	275	279	281	1893	-534	-178	-722
826	276	280	280	279	288	275	288	278	275	1894	-515	-178	-722
58	278	267	283	285	272	281	289	276	288	1894	-532	-173	-721
291	273	279	288	283	288	276	286	285	272	1894	-538	-190	-736
524	275	287	275	276	283	276	280	281	272	1893	-527	-185	-728
756	275	276	274	280	282	278	278	271	284	1894	-537	-181	-726
989	273	275	275	286	285	280	287	281	282	1893	-519	-178	-718
222	276	280	275	272	289	280	280	77	274	1894	-519	-181	-717
453	280	277	280	278	280	276	277	280	277	1894	-538	-179	-725
687	280	283	277	276	279	277	282	282	275	1894	-520	-181	-728
919	280	284	280	282	277	276	279	81	278	1893	-520	-179	-722
152	278	267	280	278	275	283	281	284	284	1894	-525	-180	-723
385	277	275	278	277	278	278	282	281	280	1893	-530	-178	-724
618	277	281	284	275	277	278	286	285	281	1894	-537	-177	-728
850	270	276	272	284	278	277	279	281	278	1894	-527	-180	-728
83	278	288	272	275	281	272	285	276	273	1893	-525	-185	-734
316	281	275	277	287	273	282	278	270	288	1894	-525	-178	-718
549	270	287	282	279	282	273	282	279	281	1893	-523	-182	-723
781	280	272	286	280	277	288	285	279	290	1894	-536	-174	-722
14	275	282	275	288	273	274	284	277	275	1894	-532	-182	-723
249	281	279	278	288	277	279	285	281	282	1894	-518	-177	-726
480	281	278	280	279	279	281	279	80	282	1894	-523	-177	-727
714	270	284	270	280	286	275	280	81	281	1894	-525	-176	-717

2.4.2 Program EWER

EWER is a data reduction program for calculating and reporting various detector and sensing parameters from the EWER device. From these calculated parameters LWC values are calculated and reported for each of the three detectors.

The input data for EWER comes from analog tapes which are recorded during flights of the Cloud Physics instrumented MC130-E aircraft. Post flight processing of the analog tapes produces digital data tapes. It is this digital tape which is used by program EWER. EWER starts at the beginning of the tape and processes all the data until two consecutive END-OF-FILE marks are found. Subsets of these digital tapes may be used as directed by user input.

There are four significant parts to program EWER. They are as follows:

1. Masking out and sorting the data in counts

An input data record consists of 204 CDC 60 bit words. Each consecutive 12 bit byte represents one word of data and must be reformatted internally into 1020 CDC words per record. Each word represents a count stored in a special format. Since 12 bits are used these words can represent values from 0 to 4096. These 12 bits represent a two's complement number. Thus if a value is greater than 2047, it has 4096 subtracted from it, resulting in the realistic value range of -2048 to 2047 (-10 to +10 volts).

2.4.2 Program EWER (cont'd)

2. Counts to volts conversion

A straight linear mapping of counts to volts is done where:

$$2047 \rightarrow 10 \text{ volts}$$
$$-2048 \rightarrow -10 \text{ volts}$$

The equation used is:

VOLTS = (.004884005)*counts + (.002441765)

Volts are stored in a separate word array. Both arrays of volts and counts are maintained for later usage.

3. Sensing parameters calculated

Freestream pressure (TORR) = A_1*volts+B_1
Delta Pressure (TRRR) = A_2*voltsB$_2$
Freestream Temperature (°C) = A_3*volts+B_3
Gap (cm) = A_4*volts+B_4

Calibration coefficients appear in table 2.2. For reporting purposes Pressure and Delta Pressure are given in MB units; using the relationship 1013.25 MB = 760 TORR.

4. Detector moisture content calculations

Three detector LWC's are calculated as follows:

2.4.2 Program EWER (cont'd)

DELTA-PRESSURE(TORRS)	=	-4.98525 * VOLTAGE - .2425
PRESSURE(TORRS)	=	80.176 * VOLTAGE + 145.001
TEMPERATURE(C)	=	-9.096 * VOLTAGE + 3.346
GAP(CM)	=	-.689 * VOLTAGE + 3.95

Table 2.2: EWER VCO calibration coefficients

2.4.2 Program EWER (cont'd)

$$(1)\ \text{COEFF} = \frac{373*P10*PRESS*N}{K1*GAP*TEMP*(PRESS+DPRESS)}$$

$$(2)\ \text{VAPOR} = \text{COEFF}(\text{LOG}_e(I_V - I_R))$$

$$(3)\ \text{COND} = \text{COEFF}(\text{LOG}_e(I_C - I_R))$$

$$(4)\ \text{LWC} = \text{VAPOR} - \text{COND}$$

Where:

P10 = 805.; water density in gm/M^3 @ 1 atmosphere, 0°C
N = .45; collection efficiency
K1 = 150; absorption coefficient in CM^{-1}
PRESS = Freestream pressure in TORR's
DPRESS = Delta pressure in TORR's
GAP = GAP in CM's
TEMP = Freestream temperature in Kelvin degrees (calculated value +273.16)
I_V = vapor moisture attenuated intensity step (counts)
I_C = vapor and condensate attenuated intensity step (counts)
I_R = reference intensity step (counts)

NOTES

(1) COEFF is valid for all the detectors for a given time
(2) If $I_V - I_R \leq 0$ set VAPOR = 0
(3) If $I_C - I_R \leq 0$ set COND = 0
(4) If LWC ≤ 0 set LWC = 0

2.4.2 Program EWER (cont'd)

The previous calculations are all incorporated into program EWER.

The capability to process subsets of the available data was included. This has two beneficial effects: First, computer processing time is reduced. Second, the amount of disk storage necessary for the retention of this data is minimized. This allows the data to be kept "on-line" which lessens throughput time necessary for running subsequent analysis programs.

All derived parameters can be written to an optional output tape. This tape is used by other analysis programs and eliminates the need to create a data base for each usage.

2.4.2.1 Program EWER operating instructions

EWER CONTROL CARDS

LALEW,T350,TP1.	ID#	ID NAME

```
ATTACH,EWERBIN,ID=GLASS,MR=1.
REQUEST,TAPE2,*PF.
VSN,TAPE1=TAPENO.
REQUEST,TAPE1,NORING,MT,L.
FILE(TAPE1,BT=E,RT=S,MBL=2040,MRL=2040,RB=1,FL=2040,BFS=206)
LDSET,PRESET=ZERO.
LGO.
EXIT(U)
CATALOG,TAPE2,PLTNAME,ID=GLASS.
7/8/9
```

EWER OPTION CARDS

LITERAL	COL 1-80 (CENTERED ON EACH PAGE OF OUTPUT)
IPLOT	COL 1 (1=PLOT TAPE PRODUCED,0=NO PLOT TAPE)
$VCALCO	COL 2-8 (REQUIRED)

VCO CALIBRATIONS MAY BE CHANGED BY INSERTING
VALUES OF ARRAY CALIB,SEPERATED BY COMMAS. (OPTIONAL)

$END	COL 2-5 (REQUIRED)
START STOP	COL 1-6 and 8-13 (PASS START AND STOP TIMES-AS MANY AS DESIRED
6/7/8/9	MAY BE USED)

2.4.2.2 EWER sample output

```
EEEEE     WW          WW     EEEEE     RRRRR
EEEEE     WW          WW     EEEEE     RRRRRR
EE         WW        WW      EE        RR   RR
EE         WW        WW      EE        RR   RR
EEEE        WW      W        EEEE      RRRRR
EEEE        WW      W        EEEE      RR RR
EE           WW  W  WW       EE        RR  RR
EE           WW WWW WW       EE        RR   RR
EEEEE         WWWWWW         EEEEE     RR    RR
EEEEE         WW   WW        EEEEE     RR     RR

[illegible]  17 FEB 8[illegible]     FINAL DATA RUN

VCO CALIBRATIONS(A+VOLTS(B+C*VOLTS))

VCO(UNITS)              A            B            C

DELTA-P(TORR)       -.24253     -4.38575     [illegible]
PRESSURE(TORR)      452.7217     54.94446    [illegible]
TEMPERATURE(C)     [illegible]   -7.97011    [illegible]
GAP(CM)             -.45102      -.91347      0.33302
```

	DETECTOR 1 MEAN	DETECTOR 1 STANDIV	DETECTOR 2 MEAN	DETECTOR 2 STANDIV	DETECTOR 3 MEAN	DETECTOR 3 STANDIV
CONDENSATE (VOLTS)	-1.751	.178	.693	.388	4.636	.654
REFERENCE (VOLTS)	-7.414	.214	-3.774	.546	-3.244	1.163
WATER (VOLTS)	-1.331	.199	.878	.557	5.540	1.178
WEIGHTING FACTOR	1.[illegible]		.5905		.4943	

TIME	LWC G/M**3 1	LWC G/M**3 2	LWC G/M**3 3	LWC G/M**3 DEFINED	DETECTOR 1 CO-RF VOLTS	DETECTOR 1 VR-RF VOLTS	DETECTOR 2 CO-RF VOLTS	DETECTOR 2 VR-RF VOLTS	DETECTOR 3 CO-RF VOLTS	DETECTOR 3 VR-RF VOLTS	DELTA-P MB	VCC PRESS MB	TEMP DEG C	GAP CM
[illegible]	.755	.131	.179	.157	1.692	2.317	4.149	4.713	9.171	9.129	5.02	521.25	-8.45	2.63
[illegible]	.733	.162	.157	.123	1.797	2.109	4.013	4.542	8.322	9.367	4.92	519.13	-8.57	2.59
[illegible]	.372	.1[illegible]	.178	.173	1.626	2.168	4.378	4.410	8.024	9.711	5.08	516.43	-8.42	2.61
[illegible]	.226	.111	.178	.142	1.679	2.471	4.31[illegible]	4.371	8.373	9.275	5.05	521.60	-8.53	2.63
[illegible]	.246	.1[illegible]	.215	.145	1.922	2.198	3.878	4.347	7.927	9.276	4.76	522.30	-8.57	2.57
[illegible]	.267	.1[illegible]	.259	.147	1.951	2.276	4.117	4.347	7.731	9.382	5.11	520.54	-8.63	2.61
[illegible]	.3[illegible]	.198	.16[illegible]	.162	1.765	2.232	4.124	4.742	8.239	9.319	4.98	519.49	-8.61	2.60
[illegible]	.45[illegible]	.299	.[illegible]	.188	1.480	2.695	4.088	4.131	7.746	9.[illegible]	4.65	521.95	-8.42	2.61
[illegible]	.726	.196	.1[illegible]	.162	1.587	2.042	3.935	4.651	8.493	9.206	4.32	521.35	-8.49	2.60
[illegible]	.374	.1[illegible]	.123	.171	1.5[illegible]	2.[illegible]	4.[illegible]	4.[illegible]	8.5[illegible]	9.[illegible]	5.[illegible]	521.25	-8.61	2.62
[illegible]	.3[illegible]	.198	.17[illegible]	.167	1.587	2.385	4.103	4.391	7.976	9.114	4.92	520.54	-8.63	2.60
[illegible]	.167	.126	.114	.099	1.971	2.129	4.373	4.493	8.288	9.055	5.11	520.54	-8.57	2.62
[illegible]	.266	.1[illegible]	.112	.17[illegible]	1.7[illegible]	2.085	4.01[illegible]	4.488	8.493	9.285	4.82	518.43	-8.49	2.59
[illegible]	.33[illegible]	.073	.1[illegible]	.142	1.695	2.198	4.249	4.198	8.215	8.919	4.98	520.39	-8.34	2.64
[illegible]	.417	.247	.266	.19[illegible]	1.6[illegible]	2.342	4.156	4.738	7.81[illegible]	9.138	4.79	524.06	-11.74	2.60
[illegible]	.381	.069	.115	.159	1.5[illegible]	2.022	4.225	4.[illegible]	8.[illegible]	8.845	4.82	519.13	-8.53	2.59
[illegible]	.763	.178	.164	.123	1.719	2.593	4.147	4.495	7.941	9.316	4.95	519.49	-8.45	2.61
[illegible]	.186	.191	.157	.1[illegible]	1.763	2.037	4.156	4.425	8.274	9.3[illegible]	5.11	518.43	-8.57	2.61
[illegible]	.3[illegible]	.116	.194	.140	1.671	2.371	4.389	4.474	8.674	9.729	5.11	520.19	-8.39	2.61
[illegible]	.276	.177	.198	.179	1.744	2.164	4.329	4.278	7.573	9.192	4.95	520.19	-8.57	2.64
[illegible]	.117	.097	.173	.1[illegible]	1.361	2.377	4.137	4.410	8.112	9.265	4.98	521.60	-8.57	2.59
[illegible]	.699	.271	.141	.37[illegible]	2.137	2.198	4.[illegible]	4.225	8.434	9.455	5.05	522.65	-8.73	2.60
[illegible]	.379	.316	.15[illegible]	.12[illegible]	1.956	2.709	4.283	4.737	8.278	9.289	4.98	519.49	-8.38	2.59
[illegible]	.408	.168	.130	.171	1.661	2.291	4.217	4.44[illegible]	8.264	9.[illegible]	5.02	519.13	-8.42	2.62
[illegible]	.3[illegible]	.174	.237	.16[illegible]	1.671	2.115	4.166	4.411	7.751	9.[illegible]	5.24	523.11	-8.61	2.59
[illegible]	.76[illegible]	.172	.187	.16[illegible]	1.607	2.129	4.127	4.576	8.513	9.109	5.28	518.76	-8.42	2.63
[illegible]	.[illegible]	.1[illegible]	.171	.376	2.351	2.213	3.966	4.764	8.[illegible]	9.143	5.18	519.43	-8.61	2.63
[illegible]	.3[illegible]	.158	.128	.166	1.617	2.125	4.[illegible]	4.523	8.[illegible]	9.[illegible]	5.18	518.43	-8.49	2.61
[illegible]	.3[illegible]	.14[illegible]	.179	.15[illegible]	1.67[illegible]	2.129	3.995	4.459	8.42[illegible]	9.3[illegible]	5.34	519.49	-8.38	2.62
[illegible]	.2[illegible]1	.073	.2[illegible]	.127	1.871	2.256	4.142	4.786	8.[illegible]	9.421	5.15	520.54	-8.49	2.63
[illegible]	.[illegible]	.1[illegible]	.179	.23[illegible]	1.451	2.212	4.074	4.464	8.198	9.294	5.11	519.13	-8.49	2.59
[illegible]	.376	.1[illegible]	.1[illegible]	.161	1.774	2.232	4.263	4.527	8.21[illegible]	9.336	4.89	521.95	-8.65	2.61
[illegible]	.[illegible]	.142	.197	.177	1.744	2.154	4.117	4.391	7.9[illegible]	9.2[illegible]	5.15	518.78	-8.14	2.63
[illegible]	.2[illegible]	[illegible]	.247	.376	1.841	2.2[illegible]3	3.6[illegible]	3.625	[illegible]	8.117	5.21	519.13	-8.43	2.63
[illegible]	.4[illegible]	.1[illegible]	.14[illegible]	.1[illegible]	1.[illegible]	2.110	4.127	4.410	8.[illegible]	9.2[illegible]	5.15	520.54	-8.65	2.61
[illegible]	.3[illegible]	.1[illegible]	.18[illegible]	.147	1.5[illegible]	2.[illegible]	4.14[illegible]	4.239	7.9[illegible]	9.[illegible]	5.15	523.54	-8.73	2.62

EWER Sample Output (cont'd)

2.4.3 Program EWERPLT

Program EWERPLT can plot, against a time axis, up to 2 lines of data. The data types are optionally chosen from the available parameters (see below). Each half hour's worth of data is plotted on a 60 inch grid. The program automatically produces these grids until the data is exhausted.

1) Voltages - nine voltages are available. They are the condensate, reference and vapor voltages for three detectors.

2) VCO's - The four VCO's are delta-pressure, pressure, temperature and gap.

3) LWC - Three calculated LWC's (see the sections on program EWER).

4) PMS-1D total LWC

The ability to plot PMS 1D LWC content values is included within program EWERPLT. With this a direct visual comparison of EWER and PMS data can be made. Either detector LWC values can be utilized with the total probe LWC's, generated by program KNOLL1D, to produce 10 x 60 inch comparative plots. The format of these plots are controlled by user directives. They decide if a scatter plot or a line plot is to be produced. If all points are to be plotted, the LWC axis limits and literals, and finally the smoothing interval desired (straight arithmetic average).

2.4.3 Program EWERPLT (cont'd)

```
CONTROL CARDS
LALEP,CM65000,T200.                    ID#              ID NAME
ATTACH,TAPE1,PMSPLTTAPE,ID=NAME,MR=1.*(TAPE2 FROM KNOLL1D)
ATTACH,TAPE2,EWERPLTTAPE,ID=NAME,MR=1.(TAPE2 FROM EWER)
ATTACH,LGO,EWERPLTBIN,ID=GLASS,MR=1.
ATTACH,PEN,ONLINEPEN,SN=SHARED,MR=1.
LIBRARY,PEN.
REQUEST,PLOT,*Q.
DISPOSE,PLOT,*PL.
LGO.
7/8/9

OPTION CARDS
CARD # 1
          COL 1-10  FLIGHT ID
          COL 11-20 LEFT AXIS LITERAL
          COL 21-30 RIGHT AXIS LITERAL*
          COL 31-35 AVERAGING INTERVAL(I5 FORMAT)
CARD # 2
          COL 1-2   LEFT AXIS PLOT NUMBER(I2 FORMAT)**
          COL 6-15  LEFT AXIS MINIMUM VALUE(F10.2 FORMAT)
          COL 16-25 LEFT AXIS MAXIMUM VALUE(F10.2 FORMAT)
          COL 26-30 LEFT AXIS PLOT FORMAT NUMBER(I5 FORMAT)***
CARD # 3
          RIGHT AXIS CARD - SAME AS # 2 ABOVE
7/8/9
6/7/8/9
```

* OPTIONAL

** PLOT NUMBERS AS FOLLOWS:

2	DETECTOR 1 CONDENSATE VOLTAGES
3	DETECTOR 1 REFERENCE VOLTAGES

2.4.3 Program EWERPLT (cont'd)

4	DETECTOR 1 VAPOR VOLTAGES
5	DETECTOR 2 CONDENSATE VOLTAGES
6	DETECTOR 2 REFERENCE VOLTAGES
7	DETECTOR 2 VAPOR VOLTAGES
8	DETECTOR 3 CONDENSATE VOLTAGES
9	DETECTOR 3 REFERENCE VOLTAGES
10	DETECTOR 3 VAPOR VOLTAGES
11	DELTA-PRESSURE IN TORRS
12	PRESSURE IN TORRS
13	TEMPERATURE IN CENTIGRADE
14	GAP IN CENTIMETERS
15	DETECTOR 1 LWC IN G/M**3
16	DETECTOR 2 LWC IN G/M**3
17	DETECTOR 3 LWC IN G/M**3
18	DERIVED DETECTOR LWC IN G/M**3
19	BEST DETECTOR LWC IN G/M**3
20	PMS DERIVED LWC IN G/M**3

*** PLOT FORMAT NUMBERS AS FOLLOWS:

>0	LINE PLOT WITH A SYMBOL EVERY N'TH POINT DEPENDING ON NUMBER CHOSEN
=0	SCATTER PLOT OF ALL POINTS
<0	SCATTER PLOT WITH EVERY N'TH POINT PLOTTED DEPENDING ON NUMBER CHOSEN

2.4.4 Program EWERPMS

EWERPMS is a program to graphically illustrate the correlation between EWER and PMS 1D generated LWC values. Program EWERPMS uses two input tapes. They are the KNOLL1D and EWER produced plot tapes which contain all necessary comparison data. The program is run interactively through INTERCOM and produces microfiche plots of PMS and EWER detector data.

PMS data is treated as a function of a EWER detector (user input) for a given averaging interval and each point is plotted separately during the pass. A least square fit line of the resultant scatter diagram is calculated and plotted. A few parameters are listed, as follows: correlation coefficient between EWER and PMS data; root mean square error estimate of the least square fit line; the least square fit line and slope and intercept and finally the respective means of the EWER and PMS devices

We should expect a good correlation of the data since similar atmosheres are being examined. We should also expect, if the equipment is working properly, slopes close to 1. This need not be the case however. Several factors can cause the slope to deviate from 1 while at the same time maintaining a good correlation.

For instance, particle typing is not necessary for the EWER detectors since the particles are melted down by the equipment and a LWC value is physcially derived at through voltage levels. On the other hand the Knollenberg device sizes then and leaves the LWC calculations to post processing

2.4.4 Program EWERPMS (cont'd)

programs such as KNOLL1D. The KNOLL1D calculation is made by algorithmically taking those measuremencs and obtaining a LWC value dependent on subjective particle typing. Even when the chosen particle predominates, erroneous results can occur since all particles must be treated similarly. While the slope may deviate, we would expect the behavior tendency to be reflected in a good correlation.

Empirical data has shown very good correlations between EWER and PMS calculated values. However, we desire a second method of determing just how good this correlation truly is.

One good method might be an analysis of the difference of the EWER and PMS values. Ideally we would expect a mean and variance of zero but we know that this will not be the case. Using the theoretical assumptions below we can calculate a confidence region for the mean value of this difference array.

An assumption we must make is that the variance of the EWER and PMS devices are equal. This is not a difficult assumption since those devices are attempting to measure the same distribution. Another assumption is that the true regression (without sampling variations) has a slope of 1.

2.4.4 Program EWERPMS (cont'd)

It can be shown that:

(1) $$T = \frac{\bar{D}\sqrt{N-1}}{\sqrt{\frac{\Sigma(D_i-\bar{D})^2}{N}}}$$

Possesses a students T distribution with N-1 degrees of freedom.

Here:
N = number of EWER, PMS pairs
$D_i = X_i - Y_i$
X_i = EWER values
Y_i = PMS values
$\bar{D}$ = D_i mean
$\bar{X}$ = EWER mean
$\bar{Y}$ = PMS mean

Substituting in X and Y for D we see that:

$$T = \frac{(\bar{X}-\bar{Y})\sqrt{N-1}}{\sqrt{\frac{\Sigma(X_i-\bar{X})^2}{N} + \frac{\Sigma(Y_i-\bar{Y})^2}{N} - \frac{2}{N}\Sigma((X_i-\bar{X})(Y_i-\bar{Y}))}}$$

$$\frac{(\bar{X}-\bar{Y})\sqrt{N-1}}{\sqrt{VAR(X)+VAR(Y)-\frac{2}{N}(\Sigma X_iY_i-\bar{X}\Sigma Y_i-\bar{Y}\Sigma X_i-\bar{X}\bar{Y})}}$$

All of the above values are now calculated by EWERPMS.

(1) Pgs. 58-63, "Some Applications of Statistics to Meteorology", Panofsky and Brier, Pennsylvania State University, 1958.

2.4.4 Program EWERPMS (cont'd)

Using the T value and the symmetry of the T distribution we then determine the probability that the magnitude of the true mean difference is greater than that of the calculated mean difference. In other words we will calculate a probability T prob that $|\bar{D}_{true}| > |\bar{D}|$.

The ultimate desire here is to use the EWER device to help fine tune the PMS values. When we attempt to make these changes it will be good to have a history of T prob, $\bar{D}$ and VAR(D) values. We can then compare the new distributions and should see a drop in the magnitude of these parameters changes.

It must be pointed out that we are not making any claims about the precision of either method for determining LWC. We are only making claims about the consistency of the two methods when compared to each other.

Operating instructions appear in section 2.4.4.1.

2.4.4.1 Program EWERPMS operating instructions

COMMAND MODE

```
LOGIN,NAME,ID,TTYNUMBER,SUP
ATTACH,CRT,CRTPLOTS,MR=1
LIBRARY,CRT.
ATTACH,TAPE1PFNAME,ID=IDNAME,MR=1     (KNOLL1D OUTPUT TAPE)
ATTACH,TAPE2,PFNAME,ID=IDNAME,MR=1    (EWER OUTPUT TAPE)
ATTACH,LGO,EWERPMSBIN,ID=GLASS,MR=1
REQUEST,TAPE39,*Q.
REQUEST,TAPE3,*Q.
```

ENTERED USER MODE - RESPOND TO QUESTIONS BELOW

```
DISPOSE,TAPE39,FM.
DISPOSE,TAPE3,PR,IAC.    (DISPOSING OUTPUT TO AC TERMINAL)
LOGOUT
```

2.4.4.1 Program EWERPMS operating instructions (cont'd)

USER MODE

INITIAL QUESTION ASKED (ONE TIME):

"INPUT FICHE LITERAL..."

RESPOND WITH UP TO A 42 CHARACTER LITERAL TO BE PHYSICALLY PLACED AT THE TOP OF EACH MICROFICHE PRODUCED BY THIS RUN.

PLOT QUESTIONS ASKED (THESE QUESTIONS ARE ASKED AS A GROUP, FOR EACH PLOT REQUESTED, UNTIL A NEGATIVE START TIME IS INPUT, WHICH CEASES THE RUN):

* "INPUT START TIME (-1 -1 -1 TO STOP)..."

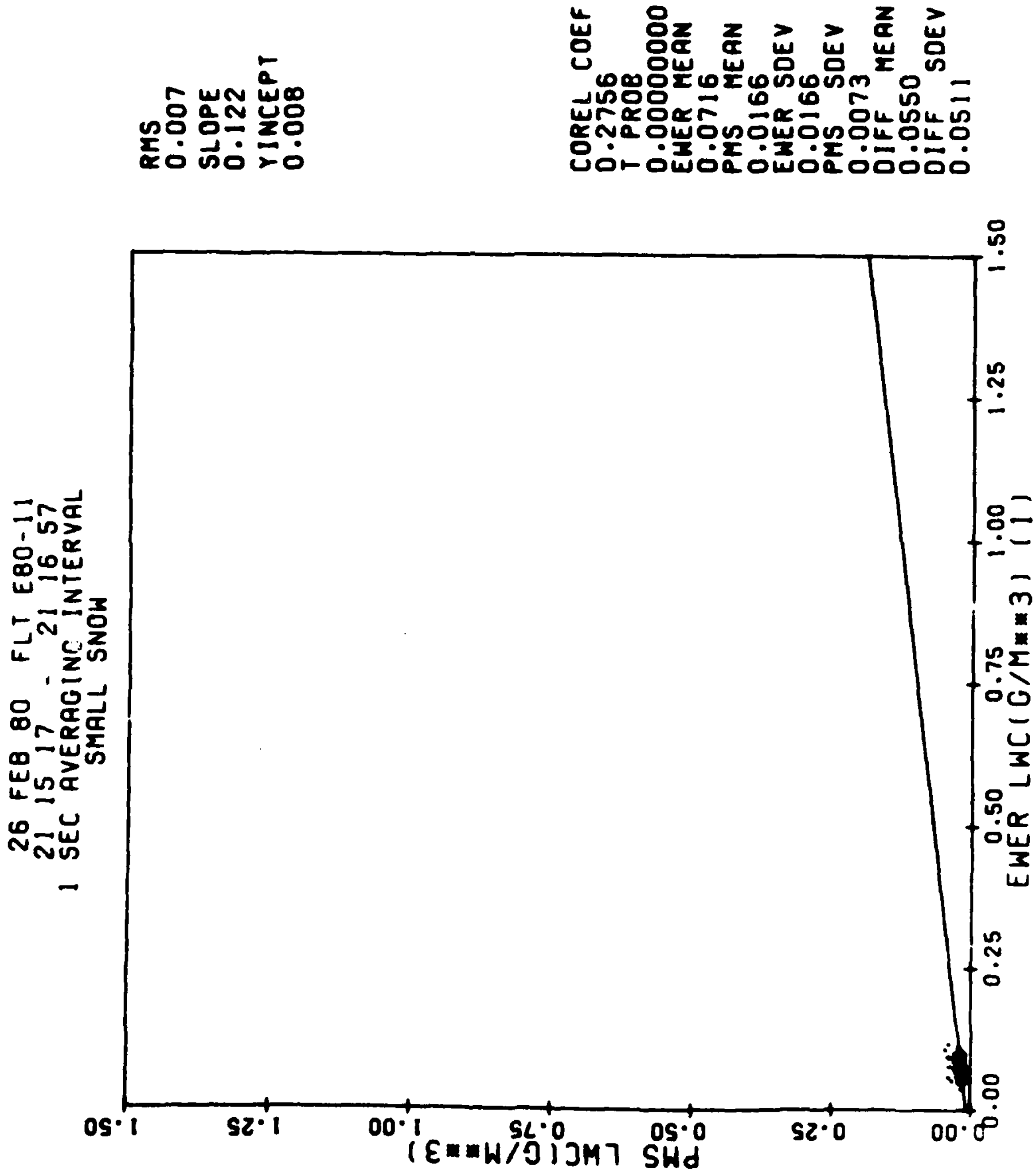
* "INPUT STOP TIME..."

"INPUT EWER DETECTOR (1,2,3)..."

"INPUT AVERAGING INTERVAL(1-60)..."

* INPUT TIME AS 3 INTEGERS IN FREE FORMAT (IH IM IS)

2.4.4.2 EWERPMS sample plot



2.4.4.3 Program EWERPMS sample output

```
                    FLT E80-11            26 FEB 80
                     24:26:05      TO     24:28:52
                              AGG F + D
                        13 SEC AVERAGING INTERVAL
                              DETECTOR 3

      PMS LWC = (      -.0636 ) * EWER LWC +        .0262

CORRELATION COEFFICEINT =  -.5142   T PROBABILITY = 1.2E-05   RMS =   .0013
               (T VALUE =   7.989   DF(N-1) =      10)
                                    PMS        EWER        DIFF
      MEAN                         .0133       .1850       .1718
      VARIANCE                     .0000       .0001       .0046
      STANDARD DEVIATION           .0016       .0115       .0680



                    FLT E80-11            26 FEB 80
                     24:32:29      TO     24:34:42
                              LARGE SNOW
                        13 SEC AVERAGING INTERVAL
                              DETECTOR 3

      PMS LWC = (       .5988 ) * EWER LWC +       -.0325

CORRELATION COEFFICEINT =    .6213   T PROBABILITY = 1.5E-01   RMS =   .0201
               (T VALUE =   1.601   DF(N-1) =       7)
                                    PMS        EWER        DIFF
      MEAN                         .1037       .2274       .1237
      VARIANCE                     .0007       .0007       .0418
      STANDARD DEVIATION           .0257       .0266       .2045
```

2.5 Ice detector analysis

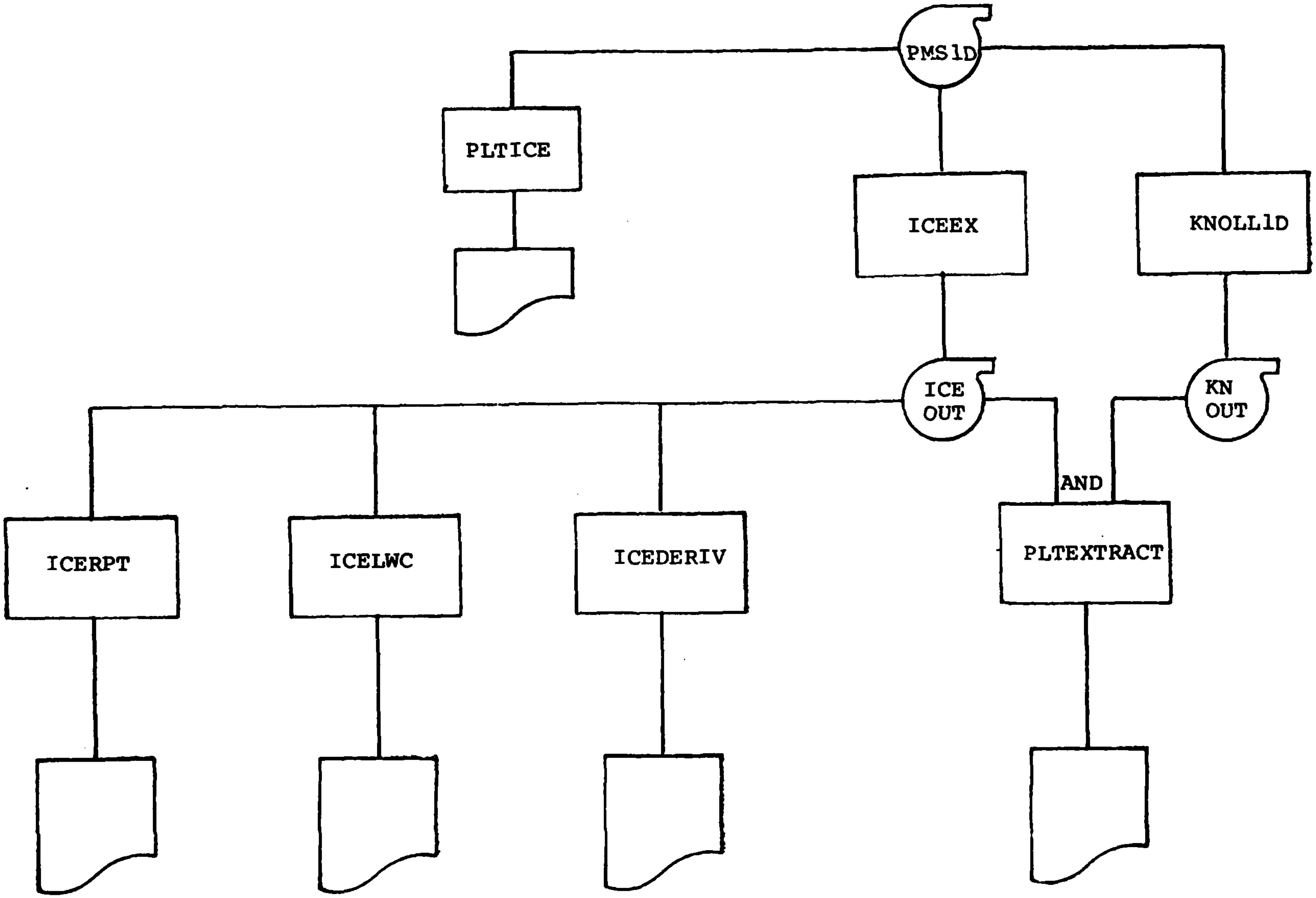
DPSI developed succeeding ice detector analysis programs during this contract period.

Aboard the C-130E, a Rosemount model 871FA ice detector is mounted vertically on the tip of the aircraft wing and data is forwarded to the VCO's and then to the PDP8 on-board the aircraft.

The icing rate is compared with radiosonde observations, liquid water content, particle distributions, temperature, dewpoint, airspeed, etc., to determine the correlation between icing rates and the ambient characteristics. The main reason for performing this analysis is to determine icing probability.

The following sections describe the programs that we developed and the analysis performed. A visual diagram of their interaction can be seen in figure 2.54.

Figure 2.54: Ice Detector Analysis Program Flow



2.5.1 Program PLTICE

In order to facilitate program design of the icing rate system PLTICE was written to plot the data as a function of time. PLTICE plots the raw counts (0-9999) on a ten-inch Y-axis, with x being scaled to 60 seconds per inch. One hour's data is plotted per fram for the duration of the flight.

PLTICE proved invaluable in the design of an analysis algorithm and can still be used to verify the proper working of the ICE detector for individual flights. Operating instructions appear below.

```
DPSI,T100,NP1.                   ACCT #    NAME
ATTACH,PEN,ONLINEPEN.
LIBRARY,PEN.
ATTACH,LGO,PLTICEBIN,ID=GLASS,MR=1.
REQUEST,PLOT,*Q.
DISPOSE,PLOT,*PL.
VSN,TAPE1=PMS#.   (KENNEDY TAPE)
REQUEST,TAPE1,S,HI.MT,NORING.
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1.BFS=105).
LGO.
7/8/9
1 DATA CARD CONTAINING MINIMUM ICING COUNT VALUE TO USE
(INTEGER-FREE FORMAT).  MAXIMUM VALUE USED IN PLOTTING
WILL BE MIN + 10000.
6/7/8/9
```

2.5.2 Program ICEEX

A flight was made on 06 DEC 79 in order to collect data using the Ice Detector device. As a "quick look" method to examine the data, a plotting program PLTICE was written (see section on PLTICE). This plot coupled with KN1UTIL VCO listing made it possible to derive certain empirical relationships between the recorded data and the behavior of the Ice Detector.

Cloud Physics scientists formulated these relationships on 19 DEC 79. Updated version of this memo is given in appendix 14. The following description of ICEEX uses these concepts.

Data from the ice detector is given in VCO position ten of the PMS 1D Kennedy tape. Program ICEEX reads this tape, identifies the modes, eliminates erroneous/redundant points, and produces an edited output tape. The Kennedy tape format is described in appendix 2 of this report.

ICEEX inputs a flight identification, a namelist card to change the default VCO calibrations, and a set of start stop time ranges.

For each start and stop time range the first standby mode is found by performing a three point running mean until this average is within 200 counts of 5250. The midpoint of this mean is then put onto the output tape with a code word equal to one. The next step is to find the "trigger value", the first count whose value exceeds 6000. Thus this marks the transition from standby to sensing mode (by ignoring the detecting mode complete17). When this time is

2.5.2 Program ICEEX (cont'd)

found (no averaging is used - only the raw count) the data record is sent with a code word equal to two. Now the ice detector is considered to be at the start of the sensing mode. Until the counts go below the "trigger value", exceed the maximum 9818 counts, or degrade into four consecutive "bad points", every data point is written to the output tape with a code word equal to three.

The cycle of finding the standby mode, trigger value, and then all sensing values is repeated until a time value exceeds the input stop time.

This inputting of start and stop times is terminated by the end of input cards or an end of file on the PMS1D tape.

Every point in the sensing mode is verified by extrapolating from the previously read two points. If the input value differs by more than 400 counts from the extrapolated value, the extrapolated value is used. The extrapolating method is designed to compromise between changing direction and having the data rise rapidly. The extrapolated point C(i) is given by

```
C(suggested) = ((C(i-2)+C(i-1))/2+2*C(i-1)-C(i-2))/2
```

Since ICEEX lists, on the printer, each value as it is being written to tape, an asterisk is printed to denote the fact that it is a "calculated" and not a "true" value. Every second worth of extracted data, as well as PMS 1D raw counts,

2.5.2 Program ICEEX (cont'd)

is written in groups of 59 words to its output tape (see appendix 13).

2.5.2.1 Program ICEEX operating instructions

```
DPSI,CM60000,T500,TP1,NT1.                 ACT #          NAME
ATTACH,LGO,ICEEXBIN,ID=GLASS,MR=1.
VSN,TAPE1=PMSTAP.    (KENNEDY)
REQUEST,TAPE1,S,HI,MT.
VSN,TAPE2=OUTTAP/NT.  (LYC WORKING TAPE)
REQUEST,TAPE2,PE,N,RING,NT.
FILE(TAPE1,RT=U,BT=k,MRL=1120,MBL=1120,RB=1,BFS=115)
LDSET,PRESET=zero.
LGO.
7/8/9
CARD 1
     COL   1-10     FLIGHT ID  (FLT XYR-XX)
          11-20     FLIGHT DATE  (DD MON TR)
             25     CLOCK 1=A/C    ,2=PMS
             30     TAPE 1=PMS    ,2=TU10
          52-59     PMS ON TIME IN FORM HH-MM-SS
CARD 2    $VCOCHAN$ NAMELIST CARDS
          (SEE VCOEF IN KNOLL1D)
CARD 3
          $JWADJ$ NAMELIST CARDS
          (SEE JWADJ IN KNOLL1D)
REMAINING CARDS
          START,STOP TIME IN FORMAT
          HH-MM-SS-HH-MM-SS
          START  STOP
6/7/8/9
```

2.5.2.2 Program ICEEX sample output

ICEEX sample output on the following page

FLT E88-02 21 JAN 80 TIME FROM 00 00 00 TO 99 99 99 PMS START 00 00 00

CODE	T I M E	ICE D	JW	TOT T	TRUE T	DEWP	PRESS	ALT	TAS	LATITUDE	LONGITUDE
SENSE	22 55 31	7459	.27	.10	-8.21	-5.12	745.3	2515	109.1	00 00 00	00 00 00
SENSE	22 55 32	7590	.32	.10	-8.21	-5.10	744.9	2519	109.2	00 00 00	00 00 00
SENSE	22 55 33	7770	.35	.08	-8.12	-5.05	744.3	2525	109.2	00 00 00	00 00 00
SENSE	22 55 34	7935	.29	.05	-7.93	-4.98	743.9	2530	109.2	00 00 00	00 00 00
SENSE	22 55 35	8097	.35	.03	-8.10	-4.93	743.3	2536	109.3	00 00 00	00 00 00
SENSE	22 55 36	8265	.37	.03	-8.06	-4.86	742.8	2541	109.3	00 00 00	00 00 00
SENSE	22 55 37	8466	.40	.02	-8.30	-4.81	742.4	2546	109.4	00 00 00	00 00 00
SENSE	22 55 38	8651	.32	.03	-8.22	-4.77	741.9	2551	109.4	00 00 00	00 00 00
SENSE	22 55 39	8858	.41	.04	-8.25	-4.75	741.3	2558	109.4	00 00 00	00 00 00
SENSE	22 55 40	9064	.45	.03	-8.32	-4.77	740.7	2564	109.6	00 00 00	00 00 00
SENSE	22 55 41	9270	.44	.03	-8.29	-4.79	740.1	2570	109.7	00 00 00	00 00 00
SENSE	22 55 42	9321*	.40	.02	-8.32	-4.80	739.8	2574	109.7	00 00 00	00 00 00
SENSE	22 55 43	8949	.42	.01	-8.40	-4.90	739.1	2581	109.7	00 00 00	00 00 00
SENSE	22 55 44	8856*	.47	-.04	-8.48	-4.98	738.4	2589	109.6	00 00 00	00 00 00
SENSE	22 55 45	8832*	.49	-.07	-8.55	-5.04	737.7	2596	109.8	00 00 00	00 00 00
SENSE	22 55 46	8826*	.48	-.13	-8.61	-5.13	737.2	2602	109.8	00 00 00	00 00 00
** STND	22 56 47	5704	.68	-.78	-9.73	-6.39	713.8	2857	112.1	00 00 00	00 00 00
-- TRIG	22 56 49	6046	.48	-.81	-9.76	-6.41	713.2	2864	112.1	00 00 00	00 00
SENSE	22 56 50	6342	.64	-.81	-9.76	-6.44	713.1	2865	112.4	00 00 00	00 00
SENSE	22 56 51	6517	.73	-.79	-9.81	-6.47	712.8	2868	112.3	00 00 00	00 00
SENSE	22 56 52	6681	.70	-.76	-9.81	-6.50	712.6	2871	112.5	00 00 00	00 01
SENSE	22 56 53	6799	.58	-.77	-9.82	-6.52	712.2	2874	112.4	00 00 00	00 06 00
SENSE	22 56 54	7002	.64	-.76	-9.82	-6.55	712.1	2875	112.6	00 00 00	00 00 00
SENSE	22 56 55	7052*	.65	-.74	-9.80	-6.58	712.1	2875	112.6	00 00 00	00 00 00
SENSE	22 56 56	7064*	.63	-.73	-9.80	-6.60	711.8	2878	112.6	00 00 00	00 00 00
SENSE	22 56 57	7067*	.61	-.69	-9.77	-6.61	711.6	2881	112.5	00 00 00	00 00 00
** STND	22 57 05	5291	.55	-.70	-9.80	-6.60	710.2	2896	112.5	00 00 00	00 00 00
-- TRIG	22 57 08	6099	.68	-.65	-9.79	-6.68	709.5	2904	112.6	00 00 00	00 00 00
SENSE	22 57 09	6348	.66	-.62	-9.76	-6.72	709.2	2907	112.5	00 00 00	00 00 00
SENSE	22 57 10	6543	.76	-.63	-9.77	-6.77	708.9	2911	112.9	00 00 00	00 00 00
SENSE	22 57 11	6718	.75	-.64	-9.79	-6.82	708.6	2914	113.0	00 00 00	00 00 00
SENSE	22 57 12	6879	.73	-.64	-9.79	-6.84	708.4	2916	112.9	00 00 00	00 00 00
SENSE	22 57 13	7256	.65	-.66	-9.82	-6.85	708.0	2921	112.9	00 00 00	00 00 00
SENSE	22 57 14	7350*	.79	-.68	-9.84	-6.88	707.6	2925	113.1	00 00 00	00 00 00
SENSE	22 57 15	7373*	.77	-.71	-9.88	-6.89	707.2	2930	113.2	00 00 00	00 00 00
SENSE	22 57 16	7378*	.64	-.75	-9.91	-6.89	706.9	2933	113.1	00 00 00	00 00 00
** STND	22 57 25	5719	.49	-.97	-10.16	-7.23	703.7	2969	113.3	00 00 00	00 00 00
-- TRIG	22 57 28	6142	.10	-1.02	-10.20	-7.32	702.4	2984	113.4	00 00 00	00 00 00
SENSE	22 57 29	6275	.17	-1.02	-10.21	-7.34	702.0	2988	113.5	00 00 00	00 00 00
SENSE	22 57 30	6351	.18	-1.05	-10.24	-7.34	701.5	2994	113.4	00 00 00	00 00 00

2.5.2.2 ICEEX Sample Output

2.5.3 Program ICERPT

Data from the ice detector is very dependent on the frequency at which the heating cycle is initiated and the rate at which the ice is collected during detecting mode. Program ICEEX separated the various operations data from the unnecessary background information. The tape is, in effect, broken down into discrete cycle intervals. Each cycle consists of the standby, trigger, and all of its detector values in the same sequence.

Thus the first analysis on the extracted data should concentrate on the rate of ice accretion and number of cycles. ICERPT is written to do this. There are two output files one for data collected during each individual cycle and another for data collected over the whole pass.

Refer to figure 2.55 and table 2.3 for the following discussion. A complete cycle is defined as the time from one standby condition to the next (HMS_{i-1} to HMS_i). The length of the cycle is DTC_i (ΔTC_i). Sampling time is defined as the time of trigger plus seven seconds to the time at which 9818 counts are exceeded (DTS_i or ΔTS_i). One parameter of interest is the average rate of ice collection (in counts) and it is found by:

$$\text{RATE} = \left[\sum_{i=2}^{N-1} (C_{i+1} - C_{i-1})/2 \right] / (N-2)$$

This equation minimizes one second fluctuations in the collection system.

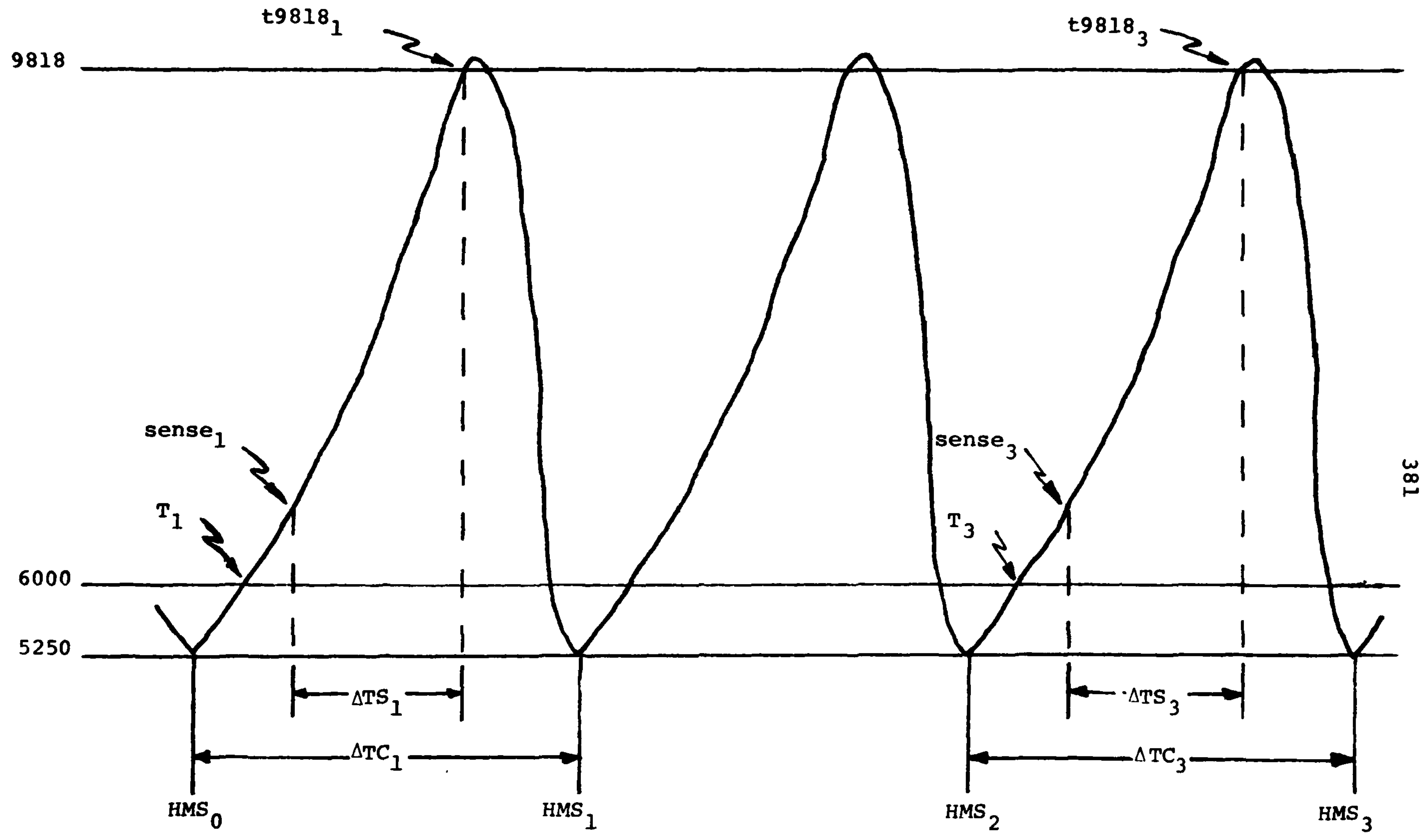


Figure 2.55: Icing Cycle

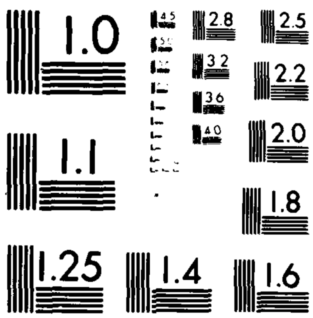
2.5.3 Program ICERPT (cont'd)

HMS_i	TIME AT WHICH STANDBY MODE OCCURS FOR CYCLE i. MARKS THE ENDING OF CYCLE i
T_i	IS THE TIME DURING CYCLE i AT WHICH COUNTS $\geq$ 6000 IS NOTED
$SENSE_i$	IS THE START OF SENSING MODE ($SENSE_i = T+7$)
$T9818_i$	IS TIME AT WHICH COUNTS > IS NOTED, OR THE FOURTH CONSECUTIVE BAD POINT IS FOUND
DTC_i	IS THE TIME OF THE CYCLE $DTC_i=HMS_i-HMS_{i-1}$ READ THE 'D' AS 'DELTA'
DTS_i	IS THE TIME OF DATA COLLECTION ($DTS_i=T9818_i-SENSE_i$) READ THE 'D' AS 'DELTA'
HMS	IS FOUND WHENEVER $ABS((COUNT_{j-1}+COUNT_j+COUNT_{j+1})/3-5250) < 200$

Table 2.3: Symbol definition for program ICERPT

AD-A109 929 DIGITAL PROGRAMMING SERVICES INC WALTHAM MASS F/G 4/2
DEVELOPMENT AND APPLICATIONS OF TECHNIQUES TO PROCESS HYDROMETE--ETC(U)
JUL 81 L E BELKSY, F B KAPLAN, J P LALLY F19628-78-C-0131
UNCLASSIFIED AFGL-TR-81-0261 NL

5 of 7
A109929



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

2.5.3.1 Program ICERPT operating instructions

```
JOBNM,CM65000,T100,NT1.                    ID #      NAME
ATTACH,LGO,ICERPTBIN,ID=GLASS,MR=1.
VSN,TAPE1=LYCXXX.  (TAPE WRITTEN BY ICEEX)
REQUEST,TAPE1,NT,NORING,E.
LDSET,PRESET=ZERO.
LGO.
EXIT(U)
REWIND,TAPE8,TAPE9.
COPY,TAPE8.
COPY,TAPE9.
7/8/9
-----DATA CARDS IN FORM *HH MM SS HH MM SS -----
6/7/8/9
```

THE ASTERISK REPRESENTS AN INITIAL BLANK. THESE ARE PASS START AND STOP TIMES IN TIME INCREASING ORDER.

2.5.3.2 Program ICERPT sample output

Table 2.4: Parameter list for program ICERPT

************PASS SUMMARY*********

A SUMMARY OF ALL THE CYCLE DATA COLLECTED WITHIN A PASS. A CYCLE IS SAID TO BE WITHIN A PASS WHENEVER FOR THE PASS START AND STOP TIMES $\leq$ $SENSE_i$ < STOP AND START < $T9818_i \leq$ STOP

1.	INPUT START TIME	
2.	INPUT STOP TIME	
3.	$SENSE_i$	(FIRST CYCLE IN PASS)
4.	$T9818_n$	(LAST CYCLE IN PASS)
5.	P_1	PRESSURE AT $SENSE_1$
6.	P_2	PRESSURE AT $T9818_n$
7.	T_1	TEMPERATURE AT $SENSE_1$
8.	T_2	TEMPERATURE AT $T9818_n$
9.	AVE H	SUM OF ALL f(P) DIVIDED BY NUMBER OF POINTS USING f AS THE STANDARD ATMOSPHERE MODEL
10.	AVE P	SUM OF ALL g(H) DIVIDED BY THE NUMBER OF POINTS USING g AS THE STANDARD ATMOSPHERE MODEL
11.	AVE T	AVERAGE TEMPERATURE
12.	AVE D	AVERAGE DEWPOINT
13.	AVE JW	AVERAGE JW-LWC
14.	JWSTD	STANDARD DEVIATION OF JW ACROSS THE PASS
15.	AVE TAS	AVERAGE TRUE AIRSPEED
16.	NUMBER OF CYCLES	
17.	SUM MASS	NUMBER OF CYCLES TIMES 0.02 GRAMS PER CYCLE (SUBJECT TO CHANGE)
18.	TOTIM	SUM OF ALL DTS_i (READ 'D' AS 'DELTA')
19.	MASS RATE	SUM MASS DIVIDED BY TOTIM
20.	AVE RATE	SUM OF ALL RATES DIVIDED BY THE NUMBER OF CYCLES

2.5.3.2 Program ICERPT sample output (cont'd)

```
PASS SUMMARY
INPUT 00 00 00 TO 93 99 99
USED  23-14-32 TO 31-29-15
AT FIRST SENSING POINT     PRESS  718.3    TEMP      .1
AT LAST  SENSING POINT     PRESS  674.7    TEMP     3.4

AVERAGES    HEIGHT  PRESSURE  TEMPERATURE  DEWPOINT  JW-LW  TRUE AIRSPEED
            4460.47   560.16       -7.32    -20.52    .38        209.17
STD DEV                                               .15

NUMBER OF CYCLES  71
SUM OF MASS     1.42
TOTAL TIME  -79669.
MASS RATE       -.00
AVE RATE        -.06
```

2.5.3.2 Program ICERPT sample output (cont'd)

Table 2.5: Parameter list for program ICERPT

***********DETAIL OUTPUT**********

ONE LINE IS PRINTED FOR EACH CYCLE ENCOUNTERED DURING A PASS

1.	CYCLE #	
2.	HMS_i	
3.	DTC	('D' IS READ AS 'DELTA')
4.	P_i	(PRESSURE AT HMS_i)
5.	AVE H_i	(AVERAGE HEIGHT FOUND BY SUMMING THE f(P) EVERY SECOND) (f(P) IS STANDARD ATMOSPHERE MODEL)
6.	T_i	(TEMPERATURE AT HMS_i)
7.	AVE JW	(AVERAGE JW ACROSS HMS_{i-1} TO HMS_i)
8.	JWS	(STANDARD DEVIATION OF JW ACROSS THE CYCLE)
9.	AVE D	(AVERAGE DEWPOINT)
10.	AVE TAS	(AVERAGE TRUE AIRSPEED)
11.	LAT_i	(LATITUDE AT HMS_i)
12.	LON_i	(LONGITUDE AT HMS_i)
13.	$SENSE_i$	(IN FORM HH:MM:SS)
14.	$T9818_i$	(IN FORM HH:MM:SS)
15.	DTS_i	(READ THE 'D' AS 'DELTA')
16.	$RATE_i$	(WHERE R_j=0.5*($COUNT_{j+1}$)-$COUNT_{j-1}$)

2.5.3.2 Program ICERPT sample output (cont'd)

CYCLE	T I M E	DIG	P(MB)	AVE ALT	TOT TEMP	AVE JW	STD JW	AVE DEW	AVE TAS	LATITUDE	LONGITUD	SENSE	LAST PT	PTS	RATE
57	00-43-07	712.	745.1	2713.2	.6	.3	.0	-5.29	166.34	00-00-00	00-00-00	00-31-24	00-42-52	688.	4.
58	00-44-29	87.	747.4	2503.0	.5	.4	.3	-3.14	159.50	00-00-00	00-00-00	00-43-16	00-44-27	71.	46.
59	00-45-07	36.	742.2	2503.3	.7	.5	.1	-4.17	163.43	00-00-00	00-00-00	00-44-41	00-45-03	22.	152.
60	00-45-40	33.	727.3	2632.8	.6	.7	.1	-3.19	181.16	00-00-00	00-00-00	00-45-19	00-45-36	17.	197.
61	00-46-16	36.	709.6	2723.1	1.6	.7	.0	-2.68	195.49	00-00-00	00-00-00	00-45-52	00-46-12	20.	160.
62	00-48-00	104.	634.4	3186.5	-4.2	.5	.1	-4.17	200.96	00-00-00	00-00-00	00-46-29	00-47-19	51.	40.
63	00-48-23	23.	621.4	3260.1	-5.2	.6	.1	-8.24	188.39	00-00-00	00-00-00	00-48-12	00-48-21	9.	204.
64	00-48-45	22.	609.4	4001.6	-6.3	.9	.1	-8.07	191.30	00-00-00	00-00-00	00-48-34	00-48-40	6.	259.
65	00-49-13	26.	598.4	4133.9	-7.3	.9	.1	-9.02	195.40	00-00-00	00-00-00	00-48-58	00-48-59	1.	0.
66	00-52-20	187.	585.6	4362.2	-5.1	.5	.2	-12.46	239.47	00-00-00	00-00-00	00-49-26	00-52-17	171.	11.
67	00-56-32	252.	532.9	4403.2	-9.6	.5	.1	-14.70	220.27	00-00-00	00-00-00	00-52-33	00-54-46	133.	-6.
68	01-11-26	894.	460.1	6069.6	-14.2	.4	.1	-45.04	252.52	00-00-00	00-00-00	00-56-49	01-11-24	875.	0.
69	01-29-16	1074.	674.7	5553.0	3.4	.4	.1	-32.24	220.75	00-00-00	00-00-00	01-11-41	01-29-15	1054.	-8.

2.5.4 Program ICEDERIV

ICEDERIV was written to study one facet of ice detector analysis. That is a comparison of how ice detector VCO values (counts) vary over time with the amount of water observed by the JW-LWC and PMS-1D axial probe devices.

The analysis first concerns itself with the rate at which the VCO readings (ice detector counts) vary; in other words the derivative of the ice detector VCO values. The first problem with numerically calculating a derivative is in choosing the neighborhood over which it is to be computed. The second problem is that this derivative calculation is extremely sensitive to minor fluctuations in the neighborhood in which it is computed.

The solution to the first problem is to calculate the derivatives over various time intervals and deduce the best one to use. The second problem requires a smoothing function to be applied to the data and then utilize a derivative method to realize the rates of change.

APPLIED ANALYSIS, by C. Lanczos (Prentice Hall 1961) pages 321-324 gives a method to smooth the data and to compute the derivatives. The following is a mathematical description of the icing rate calculation algorithm encoded in program ICEDERIV.

The method calculates a smooth polynomial of degree 2K (where K is the number of points on each side of the point at which the derivative is to be computed) and then develops

2.5.4 Program ICEDERIV (cont'd)

its derivative. The general formula for the derivative of f at x with K neighbors on each side for equally spaced one second data is then

$$f^1(x) = \sum_{\alpha=-K}^{+K} \alpha f(x+\alpha) / s \sum_{\alpha=1}^{K} \alpha^2)$$

The above formula works for K $\geq$ 2.

This method requires the point which the derivative is to be computed to be in a neighborhood of K points. Thus for the first two and last two points the general formula fails.

The way to derive these values is to compute a least square second degree fit and use its normal equations:

$$f^1(1) = (-21f(1)+13f(2)+17f(3)-9f(4))/20$$
$$f^1(2) = (-11f(1)+3f(2)+7f(3)+f(3))/20$$

The last two points (xmax, xmax-1) are comparably calculated

$$f^1(xmax) = (21f(xmax-13f(xmax-1)-17f(xmax-2)+9f(xmax-3))/20$$
$$f^1(xmax-1) = (11f(xmax)-3f(xmax-1)-7f(xmax-2)-f(xmax-3))/20$$

ICEDERIV was originally written to accept an ICEEX output tape, and for each data point calculate the derivative, using 2, 3, 4, 5, 6, and 7 neighboring points. The table printed by ICEDERIV is broken at every new icing cycle and contains the ICE count, time and derivatives.

2.5.4 Program ICEDERIV (cont'd)

Cloud Physics Branch scientists determined that a 2 point derivative was sufficient for our application; thus the remaining rates were deleted from its output.

Since the comparison is to be made with JW-LWC or PMS 1D AXIAL these other two parameters were added to the table. These data sources are also subject to one second "noise" and were smoothed. A five point smoothing formula is given in APPLIED ANALYSIS pages 316-320.[1] The reasoning used for five points and not a higher number is that these LWC devices give "INSTANT" readings and as such they do give verifying answers from second to second. A longer smoothing interval would hide the data behavior while a short period would simply average the sample "noise".

For any given point x_i the smoothing formula is:

$$f_{smooth}(x_i)=[-3f(s_{i-2})+12f(x_i-1)+17f(x_i)+12f(x_{i+1})-3f(x_{i+2}]/35$$

for the first two points $f(x_1)$, $f(x_2)$:

$$f_{smooth}\ (x_1)\ =\ f(x_1+\Delta^3 f(x_1)/5+\Delta^4 f(x_1)3/35$$

$$f_{smooth}\ (x_2)\ =\ f(x_2)-\Delta^3 f(x_1)2/5-\Delta^4 f(x_1)1/7$$

[1]Applied Analysis, by C. Lanczos (Prentice Hall 1961), pages 321-324.

2.5.4 Program ICEDERIV (cont'd)

where:

$$\Delta^3 f(x_1) = f(x_4) - 3f(x_3) + 3f(x_2) - f(x_1)$$

$$\Delta^4 f(x_1) = f(x_5) - 4f(x_4) + 6f(x_3) = 4f(x_2) + f(x_1)$$

for the last two points $f(x_{max})$, $f(x_{max-1})$:

$$f_{smooth}(x_{xmax}) = f(x_{xmax}) - \Delta^3 f(x_{xmax}) 1/5 + \Delta^4 f(x_{xmax}) 3/35$$

$$f_{smooth}(x_{xmax-1}) = f(x_{xmax-1}) + \Delta^3 f(x_{xmax}) 2/5 - \Delta^4 f(x_{xmax}) 1/7$$

where:

$$f(x_{xmax}) = f(x_{xmax}) - 3f(x_{xmax-1}) + 3f(x_{xmax-2}) - f(x_{xmax-1})$$

$$f(x_{xmax}) = f(s_{max}) - 4f(s_{max-1}) + 6f(x_{xmax-2}) - 4f(x_{xmax-3}) + f(x_{max-4})$$

All the above equations in addition to the liquid water calculating module (for the JW-LWC and AXIAL probe devices) from KNOLL1D were encoded into ICEDERIV.

An additional feature of the program is the calculation of total pass LWC. Subroutine SIMPSON calculates the total water content measured during every icing cycle. SIMPSON uses two separate methods. SIMPSON's and the trapezoidal rules of numerical integration are used (see: "Introduction to Numerical Analysis:, by F. B. Hildebrand, pages 91-95).

2.5.4 Program ICEDERIV (cont'd)

Totals by both methods are calculated for the following: JW-LWC, JW-LWC smoothed data, PMS-1D LWC, and PMS-1D LWC smoothed data. Answers are presented at the end of the output for each icing cycle.

2.5.4.1 Program ICEDERIV operating instructions

```
  CONTROL CARDS
  DPSI,CM100000,T400,NT1.              ID#       ID NAME
  ATTACH,CRT,CRTPLOTS,MR=1,SN=SHARED.
  LIBRARY,CRT.
  REQUEST,TAPE39,*Q.
* VSN,TAPE1=LYCXXX/NT.
  REQUEST,TAPE1,NT,E,NORING.
  LGO,PL=99999999.
  EXIT(U)
  DISPOSE,TAPE39,FM.
  REWIND,TAPE2,TAPE3,TAPE4.
  COPY,TAPE2
  COPY,TAPE4
  COPY,TAPE3
  7/8/9
  6/7/8/9
* OUTPUT FILE FROM PROGRAM ICEEX
  DATA CARDS (AS MANY AS NEEDED IN TIME ORDER)
  CC                         DESCRIPTION
  1-2       MIN-PMS PROBE MINIMUM CHANNEL # TO USE
            (I2 FORMAT - DEFAULT ZERO)
  3-4       MAX-PMS PROBE MAXIMUM CHANNEL # TO USE
            (I2 FORMAT - DEFAULT 15)
* 11-16     START - PASS STOP TIME IN FORM HHMMSS
* 18-23     STOP - PASS STOP TIME IN FORM HHMMSS
* 31-35     FCYC - FIRST PASS CYCLE (I5 FORMAT)
* 36-40     LCYC - LAST PASS CYCLE (I5 FORMAT)
  46-50     PLIT - PASS IDENTIFIER (A5 FORMAT)
```

* either or both pass times and cycle numbers may be used.

2.5.4.2 Program ICEDERIV sample outputs

ICEDERIV now produces the following output (PLEASE NOTE THAT THE PREVIOUS SECTIONS AND THOSE OF KNOLL1D ILLUSTRATE THE METHODS INVOLVED IN MAKING THE APPROPRIATE CALCULATIONS.

A. Standard Output File for every cycle

1. second by second listing of the following parameters
   ICE COUNT
   2 PT RATE
   * JW-LWC
   * JW-LWC (SMOOTH)
   * PMS1D-LWC
   * PMS1D-LWC (SMOOTH)
   PMS MVD
   DEWPOINT DEPRESSION (TRUE TEMP - DEWP)
   PRESSURE
   ALTITUDE
   TRUE TEMPERATURE
   TOTAL TEMP

2. Simpson's and trapezoidal rule calculation for each of the four LWC's above (*)

3. mean values of DEWPOINT DEPRESSION through TOTAL TEMP in the list above. Also the DEWPOINT DEPRESSION and TRUE TEMP standard deviations.

2.5.4.2 Program ICEDERIV sample outputs (cont'd)

4. Calculated least square fit lines and correlations of the following pairs:

JW-LWC	-	PMS-LWC
RATE	-	JW-LWC
RATE	-	JW-LWC (SMOOTH)
RATE	-	PMS1D-LWC
RATE	-	PMS1D-LWC (SMOOTH)

B. TAPE2 Output File
Cycle summary data file containing one line of data for each cycle above.

C. TAPE3 Output File
Pass summary data file containing averages for every cycle within a pass.

D. TAPE4 Output File
Contains a one line summary of least square fit line coefficients for every cycle

NOTE: B and C above contain most of the parameters found in A-1

Additionally ICEDERIV produces graphic output on 105mm microfiche. The following plots are produced.

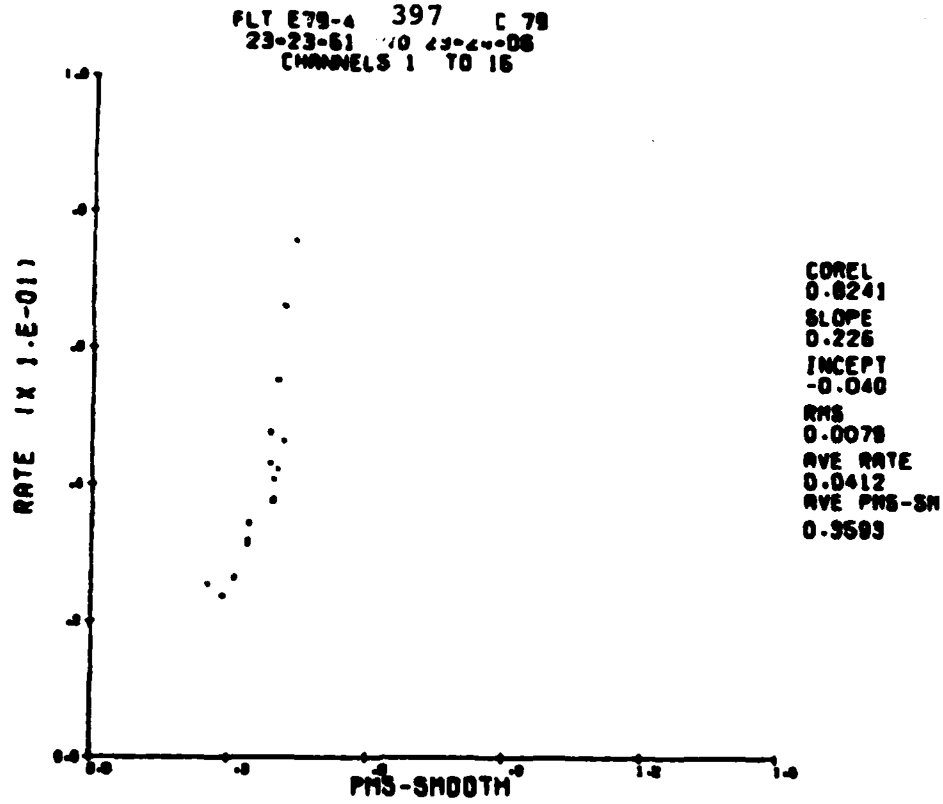
A. FOR EVERY CYCLE OF A PASS
1. Log normalized number density vs channel size
2. Scatter plot of PMS 1D-LWC (SMOOTH) vs channel size
3. Scatter plot of JW-LWC (SMOOTH) vs channel size

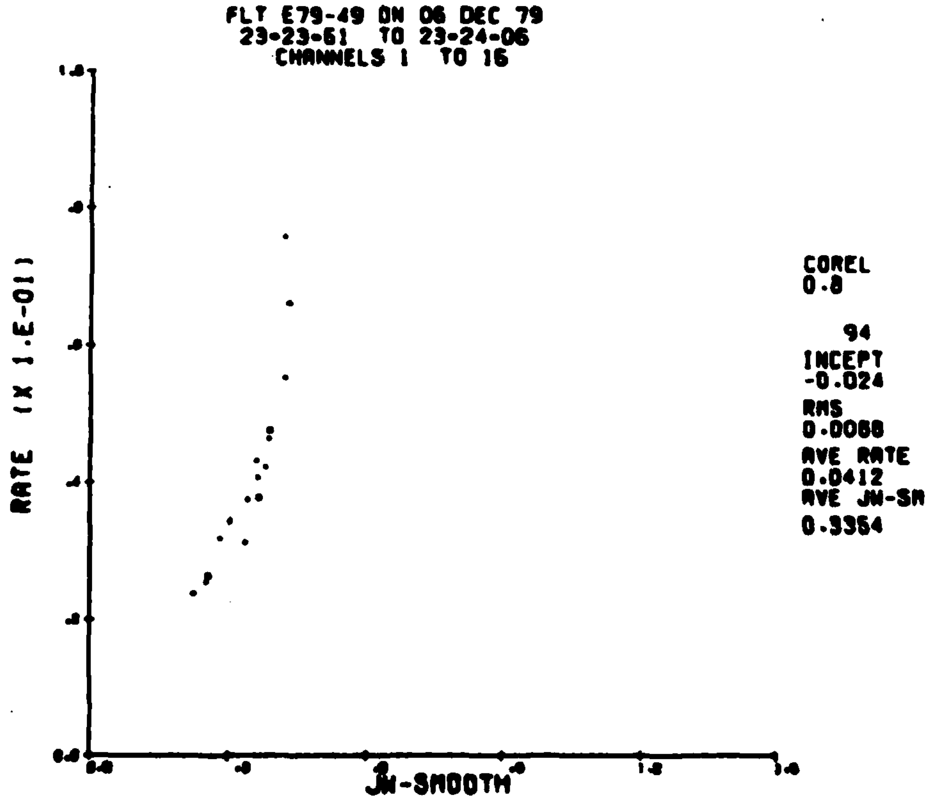
2.5.4.2 Program ICEDERIV sample outputs (cont'd)

4. time plot containing: rate, PMS 1D-LWC (SMOOTH), and JW-LWC (SMOOTH)
5. rate vs PMS1D-LWC (SMOOTH) scatter plot
6. rate vs JW-LWC (SMOOTH) scatter plot

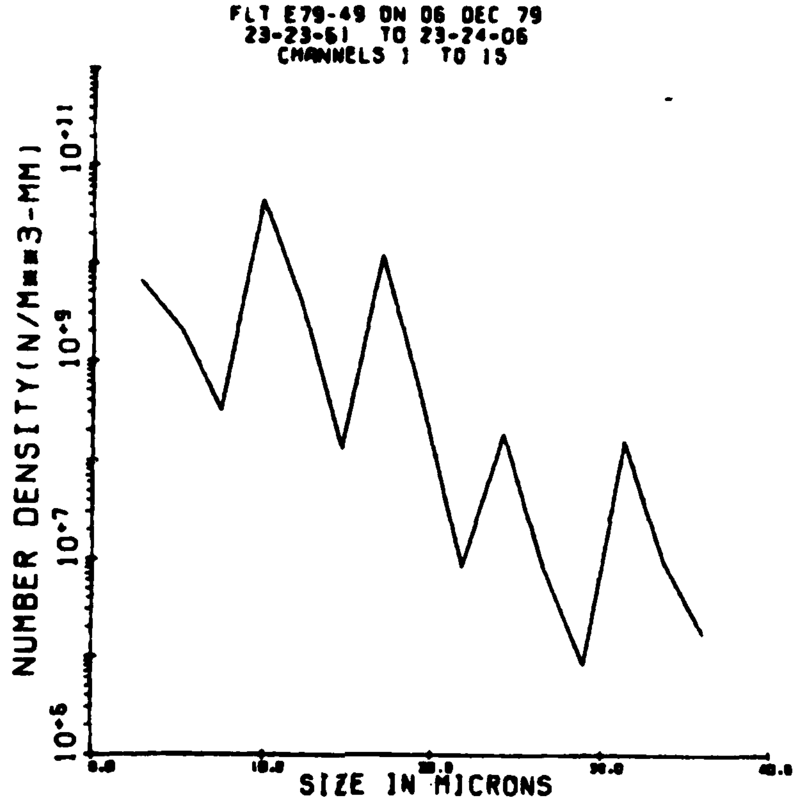
B. FOR EVERY PASS

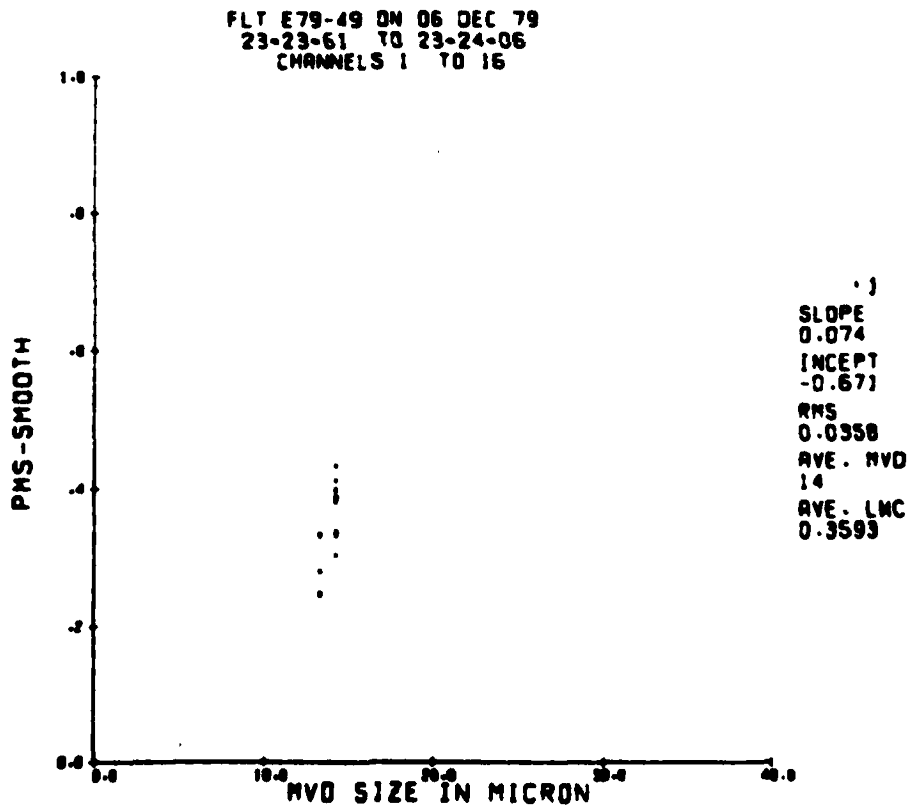
1. scatter plot of JW-LWC vs PMS1D-LWC
2. Log normalized number density vs channel size



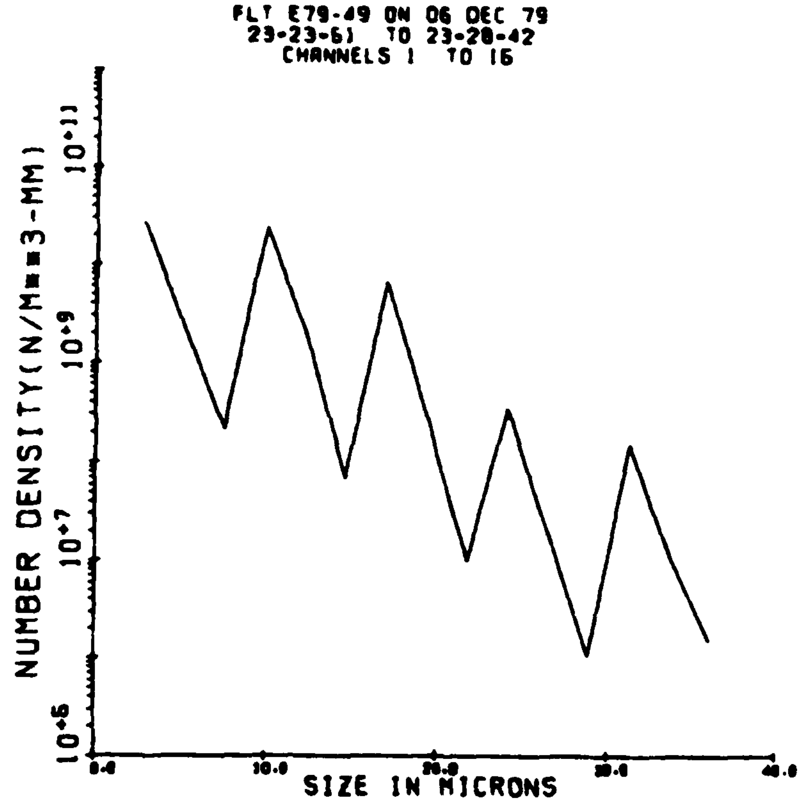


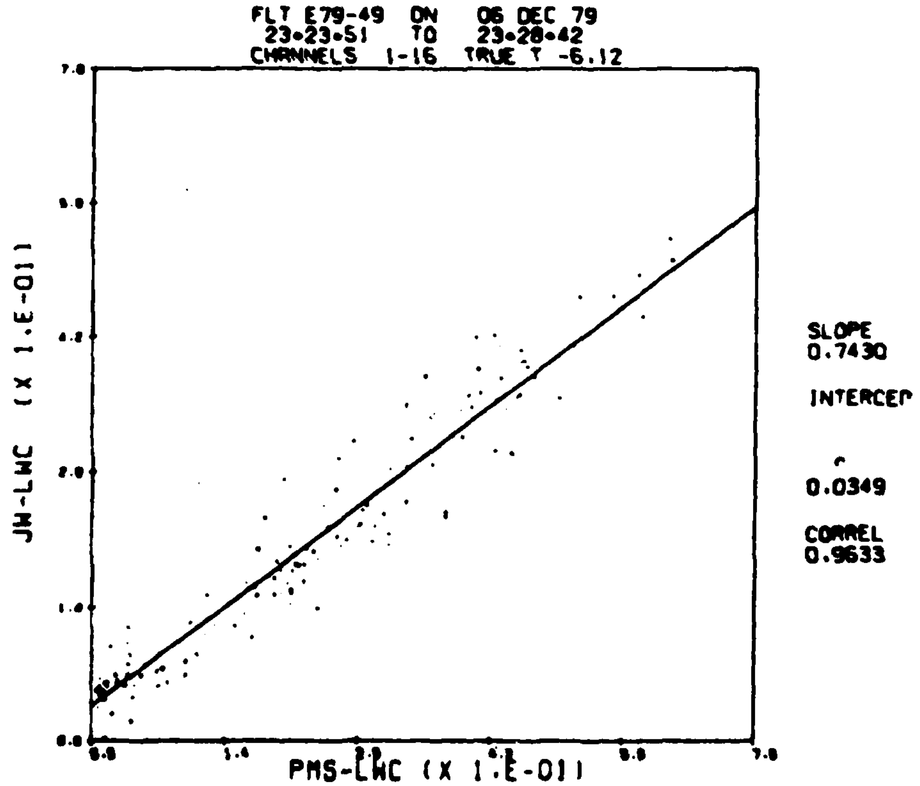
ICEDERIV Sample Plot (CYCLE)



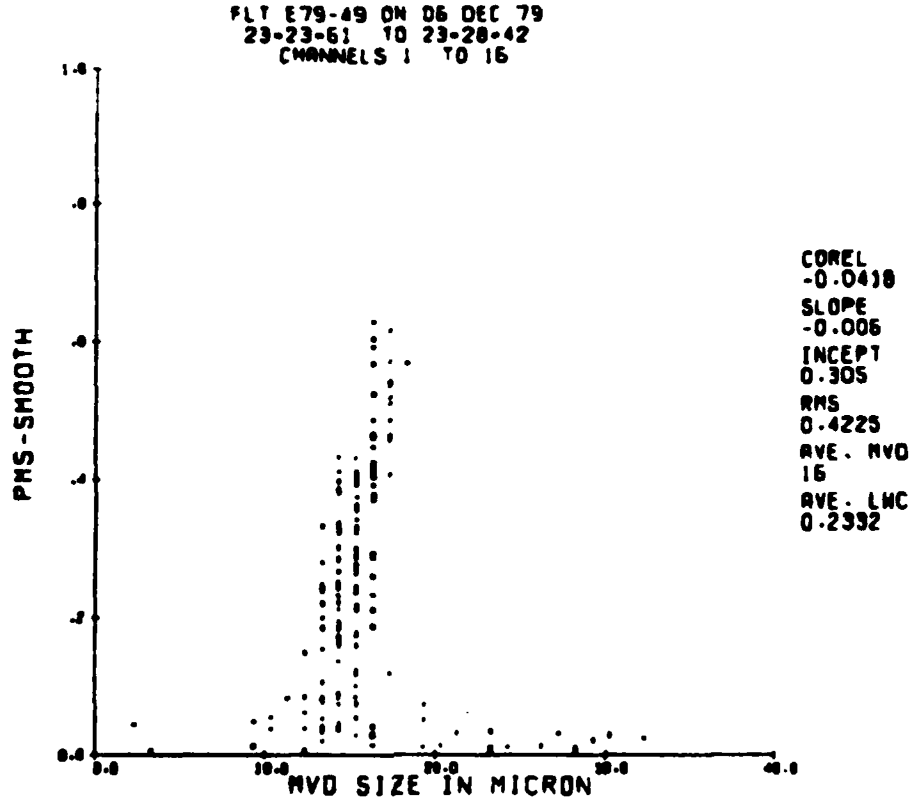


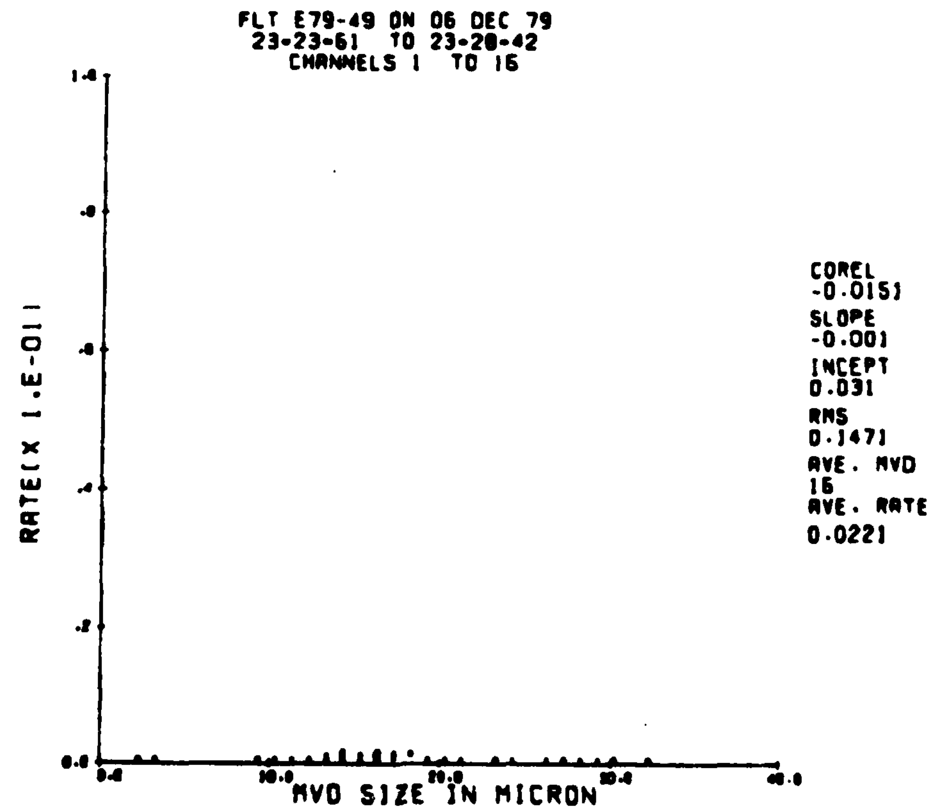
ICEDERIV Sample Plots (CYCLE) cont'd



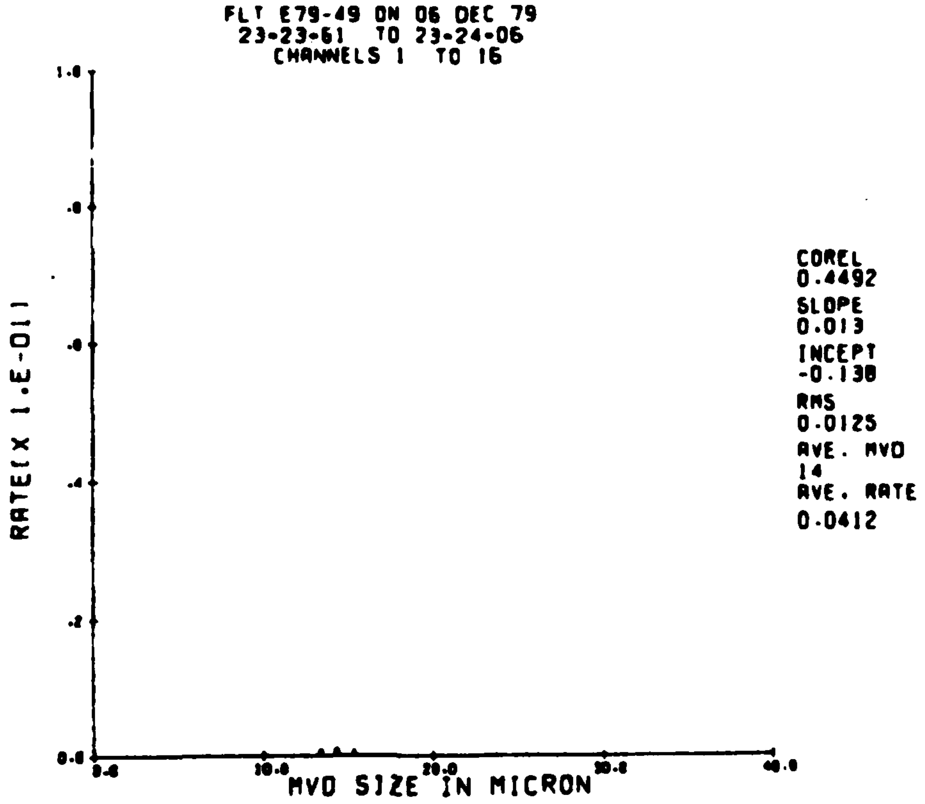


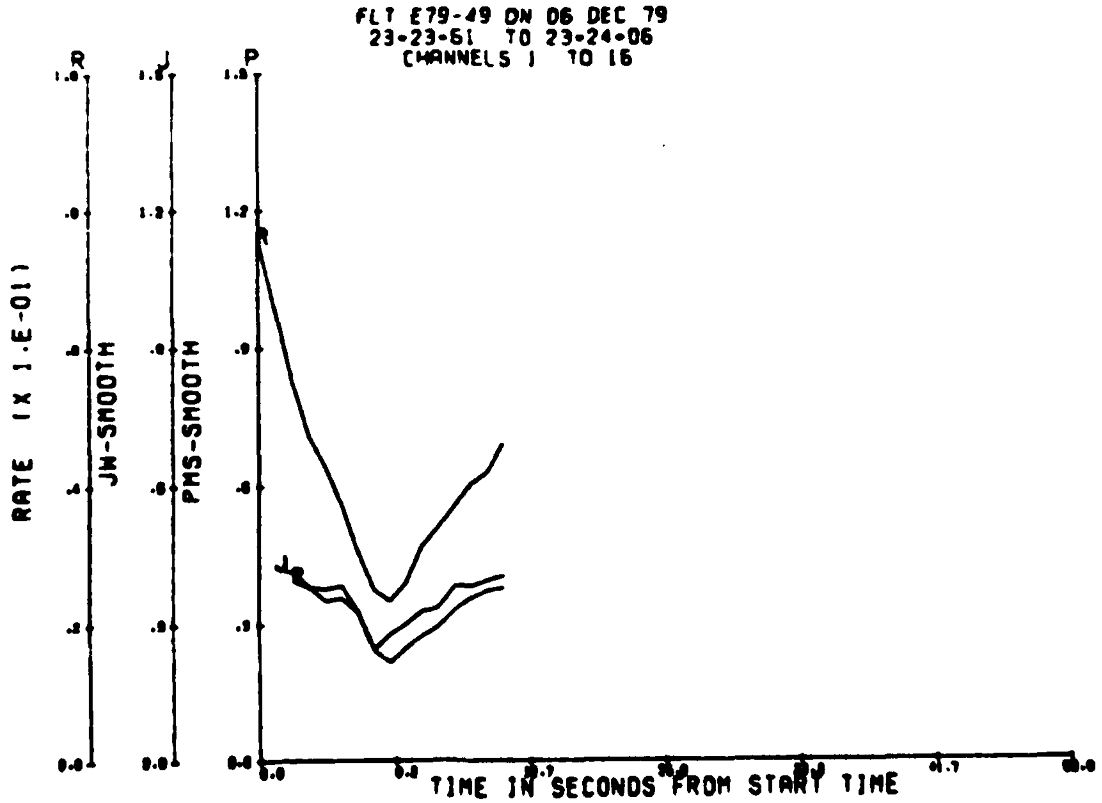
ICEDERIV Sample Plots (cont'd)
(PASS)





ICEDERIV Sample Plots (cont'd)
(PASS)





ICEDERIV Sample Plots (cont'd)
(PASS)

THIS CYCLE BEGINS AT 24-35-43   FLT 180-03 17 DEC 80   CHANNELS 17-45   TYPE C1   RAIN   CYCLE # 66

SECONDS	ICE COUNT	2 POINT RATE	JW LWC	JW SMOOTH	PMS-11 LWC	PMS-11 SMOOTH	MVD (MU)	DEWP DEPRES	PRESS (MB)	HEIGHT (METERS)	TRUE TEMP	TOTAL TEMP		
0	7533.	.1925	.2691	.2678	.5575	.5521	219	-1.1015	691.23	3121.23	-5.51	-1.54		24-35-43
1	7953.	.0782	.2729	.2763	.6323	.6123	172	-.9855	690.13	3122.42	-5.49	-1.57		24-35-44
2	9142.	.0596	.2552	.2528	.5365	.6223	217	-1.0313	690.03	3127.56	-5.54	-1.61		24-35-45
3	3347.	.0491	.1375	.1035	.57 [illegible]	.5[illegible]3	174	-1.1022	69[illegible]	3122.56	-5.61	-1.63		24-35-46
4	3423.	.0453	.1792	.2472	.5973	.4595	191	-1.1218	691.03	3123.56	-5.63	-1.63		24-35-47
5	6646.	.0563	.1626	.1311	.7611	.4396	166	-1.1057	691.03	3123.56	-5.61	-1.66		24-35-48
6	3863.	.0762	.1673	.1267	.5507	.4574	188	-1.1065	689.93	3124.70	-5.61	-1.56		24-35-49
7	3232.	.0595	.3136	.2914	.6313	.5339	256	-1.1566	69[illegible].93	3124.73	-5.57	-1.60		24-35-50
SIMPSON'S RULE			1.43	1.44	3.732	3.722								
TRAPIZOIDAL RULE			1.45	1.45	3.735	3.710		-1.06	691.04	3123.42	-5.57	-1.62	MEAN	
								.05			.05		STDEV.	

CORRELATION COEFFICIENTS

.4661	JW-LWC	VS	PMS-LWC
.7254	JW-LWC	VS	PMS-SMOOTH
.5383	JW-SMOOTH	VS	PMS-LWC
.7122	JW-SMOOTH	VS	PMS-SMOOTH

```
JW-LWC      =    .3720  X ( PMS-LWC )  +    .1126
 CORRELATION     .466
 REG. RMS             .0381
 INV. RMS             .1305

 RATE       =    .2013  X ( JW-LWC )  +    .0246
 CORRELATION     .759
 REG. RMS             .0169
 INV. RMS             .0544

 RATE       =    .2194  X ( JW-SMOOTH )  +    .0205
 CORRELATION     .742
 REG. RMS             .0173
 INV. RMS             .0468

 RATE       =    .0405  X ( PMS-LWC )  +    .0465
 CORRELATION     .141
 REG. RMS             .0165
 INV. RMS             .4071

 RATE       =    .0532  X (PMS-SMOOTH )  +    .0399
 CORRELATION     .215
 REG. RMS             .0164
 INV. RMS             .3086
```

ICEDERIV Sample Output

CYCLE SUMMARY DATA

CYCLE NO.	REFERENCE TIME	START TIME	STOP TIME	T	[illegible]/T	[illegible]Z/T	[illegible]Z/T	ALT (M)	PRESS (MB)	TOTAL TEMP	TRUE TEMP	TRUE T STDEV.	DEWP DEPRS	D DTP STDEV.	NVP	CHANNEL MIN	CHANNEL MAX
1	22:32:49	22:32:31	22:33:07	37	.0270	.00731	.01117	5314.0	483.9	-15.7	-21.3	.221	-.9	.167	16	17	45
2	22:36:47	22:33:25	22:40:37	393	.0025	-.06273	.00927	6160.6	461.4	-13.6	-21.3	.479	2.4	1.371	251	17	45
3	23:12:04	23:11:53	23:12:15	22	.0453	.24672	.04030	2644.0	733.3	1.5	-2.8	.393	2.9	.973	17	17	45
4	23:13:22	23:12:30	23:14:14	104	.0096	.35392	.02232	2246.0	770.3	2.	-1.0	.234	2.1	.672	7	17	45
5	23:37:35	23:37:05	23:37:4[illegible]	29	[illegible]	.24201	.15066	2537.5	743.2	1.[illegible]	-2.1	.092	-1.3	.259	16	17	45
6	23:38:23	23:38:06	23:38:37	31	.0327	.22075	.17027	2524.9	744.4	1.3	-1.4	.041	-1.2	.112	16	17	45
7	23:39:24	23:39:01	23:39:47	46	.0217	.11365	.09420	2518.9	745.3	2.2	-1.4	.098	-.7	.166	16	17	45
8	23:40:46	23:40:36	23:41:12	76	.0132	.12626	.07212	2535.5	743.4	2.1	-1.6	.134	-1.0	.155	15	17	45
9	23:42:05	23:41:43	23:42:27	43	.0227	.07869	.05942	2530.7	743.9	1.5	-1.8	.085	-.9	.097	16	17	45
10	23:42:54	23:42:46	23:43:03	17	.0588	.18453	.16253	2528.2	744.1	1.7	-1.9	.028	-1.1	.062	17	17	45
11	23:43:35	23:43:23	23:43:55	32	.0313	.11212	.10976	2525.5	744.3	1.[illegible]	-1.7	.162	-.9	.121	16	17	45
12	23:44:35	23:44:27	23:44:49	22	.0455	.13467	.14271	2687.1	729.7	1.2	-2.6	.220	-1.1	.095	15	17	45
13	23:45:31	23:45:06	23:45:57	51	.0196	.06216	.06453	2816.7	717.5	.2	-3.5	.156	-1.1	.366	15	17	45
14	23:46:26	23:46:18	23:46:34	15	.0625	.14377	.11617	2819.6	717.2	.2	-3.7	.063	-.9	.114	19	17	45
15	23:47:22	23:47:19	23:47:26	7	.1429	.23607	.16952	2863.9	713.3	-.2	-4.2	[illegible]	-1.3	.059	16	17	45
16	23:47:54	23:47:46	23:48:02	16	.0625	.19560	.14513	2848.5	714.6	-.1	-4.0	.043	-1.2	.046	18	17	45
17	23:48:56	23:48:51	23:49:01	10	.1000	.23273	.15260	2851.9	714.3	-.1	-4.1	.047	-1.1	.047	17	17	45
18	23:49:25	23:49:21	23:49:35	14	.0714	.13127	.08351	2849.3	714.5	-.2	-4.1	.040	-1.1	.093	17	17	45
19	23:50:24	23:49:57	23:50:51	54	.0185	.07725	.05140	2853.6	715.0	-.1	-3.9	.058	-.8	.126	18	17	45
20	23:51:27	23:51:12	23:51:43	31	.0323	.06632	.06296	2891.2	710.7	-.3	-4.0	.210	-1.1	.174	17	17	45
21	23:52:29	23:52:11	23:52:45	34	.0294	.07373	.09203	3127.6	690.5	-1.1	-5.2	.114	-.9	.066	17	17	45
22	23:53:10	23:53:04	23:53:17	13	.0769	.17917	.11727	3131.6	689.3	-1.7	-5.6	.043	-1.4	.352	19	17	45
23	23:53:39	23:53:36	23:53:43	7	.1111	.15954	.10904	3122.2	690.1	-1.5	-5.6	.275	-1.1	.255	19	17	45
24	23:54:36	23:54:01	23:55:11	71	.0143	.05659	.02966	3123.1	690.1	-1.5	-5.5	.087	-.7	.191	16	17	45
25	23:56:40	23:55:23	23:56:57	34	.0234	.06925	.06716	3131.9	689.3	-1.5	-5.5	.051	-.4	.167	16	17	45
26	23:57:36	23:57:30	23:57:43	13	.0769	.26042	.17063	3123.6	690.0	-1.7	-5.6	.044	-.6	.035	20	17	45
27	23:58:02	23:58:02	23:58:14	12	.0833	.19914	.14987	3120.2	690.3	-1.6	-5.7	.072	-1.0	.166	19	17	45
28	23:59:05	23:58:53	23:59:18	25	.0400	.10915	.07666	3131.7	689.3	-1.6	-5.6	.063	-1.1	.193	16	17	45
29	23:59:49	23:59:36	24:00:02	26	.0385	.11279	.06825	3129.7	689.5	-1.7	-5.6	.192	-1.2	.161	19	17	45
30	24:00:39	24:00:37	24:00:41	4	.2500	.23443	.16856	3132.9	689.2	-1.6	-5.9	.033	-1.3	.030	16	17	45
31	24:01:13	24:01:02	24:01:24	22	.0455	.10521	.07605	3127.5	689.7	-1.5	-5.5	.137	-.6	.103	18	17	45
33	24:02:44	24:02:38	24:02:50	12	.0833	.15569	.10641	3462.9	660.7	-3.5	-8.0	.142	-1.2	.111	19	17	45
40	24:06:17	24:06:09	24:06:25	16	.0625	.16192	.00351	3450.6	661.7	-3.7	-7.0	.075	-1.1	.094	236	17	45
41	24:07:31	24:07:24	24:07:38	14	.0714	.10978	.00146	3446.1	661.9	-3.6	-7.7	.030	-.6	.071	229	17	45
42	24:09:25	24:07:59	24:10:53	174	.0057	-.00223	.00117	3723.3	640.5	-3.7	-8.2	.237	-.3	2.260	219	17	45
43	24:26:07	24:26:07	24:26:08	1	1.0000	.51552	.25257	3145.2	686.1	-1.7	-5.6	.044	-.0	.075	19	17	45
44	24:26:36	24:26:31	24:26:41	10	.1000	.15209	.08357	3131.6	689.4	-1.4	-5.5	.059	-.3	.069	19	17	45
45	24:27:04	24:27:04	24:27:05	1	1.0000	.50557	.21161	3130.4	689.4	-1.7	-5.7	.040	-.3	.040	19	17	45
46	24:27:27	24:27:26	24:27:27	2	.5000	.30956	.30700	3128.1	689.6	-1.4	-5.6	.120	-.3	.111	19	17	45
47	24:27:44	24:27:44	24:27:45	1	1.0000	.34902	.22000	3129.2	689.5	-1.6	-5.7	.055	-.6	.260	19	17	45
48	24:28:23	24:28:23	24:28:24	1	1.0000	.45222	.25900	3125.7	689.9	-1.6	-5.6	.010	-.6	.066	19	17	45
49	24:28:41	24:28:41	24:28:42	1	1.0000	.66775	.29490	3125.9	689.8	-1.7	-5.3	.019	-.4	.016	19	17	45
51	24:29:35	24:29:35	24:29:36	1	1.0000	.65390	.33631	3123.0	690.1	-1.7	-5.3	.020	-.4	.096	19	17	45
52	24:29:52	24:29:52	24:29:53	1	1.0000	.39155	.21757	3110.4	690.5	-1.7	-5.6	.009	-.1	.004	19	17	45
53	24:30:13	24:30:13	24:30:14	1	1.0000	.65231	.32560	3120.7	690.3	-1.7	-5.1	.029	-.7	.020	19	17	45
55	24:30:55	24:30:52	24:30:59	7	.1429	.76396	.26240	3122.7	690.1	-1.7	-5.3	.154	-1.2	.455	17	17	45
56	24:31:25	24:31:20	24:31:37	17	.0588	.49521	.31120	3233.2	689.2	-1.4	-5.6	.134	-.9	.192	15	17	45
57	24:32:01	24:31:57	24:32:06	9	.1111	.46465	.33767	3130.2	689.4	-1.1	-5.1	.057	-.4	.064	14	17	45
58	24:32:25	24:32:26	24:32:27	1	1.0000	.75566	.42037	3131.4	689.4	-1.7	-5.7	.015	-1.2	.010	20	17	45
59	24:32:46	24:32:45	24:32:48	3	.3333	.46410	.36066	3128.7	689.6	-1.7	-5.2	.013	-.7	.010	12	17	45
60	24:33:09	24:33:06	24:33:11	5	.2000	.66276	.43950	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.065	10	17	45
61	24:33:27	24:33:26	24:33:29	3	.3333	.42012	.72[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.123	14	17	45
62	24:33:49	24:33:47	24:33:52	5	.2000	.34025	.33987	3130.6	[illegible]	-.[illegible]	[illegible]	.156	-.5	.364	12	17	45
63	24:34:10	24:34:09	24:34:11	2	.5000	.31660	.70047	3127.3	689.7	-1.[illegible]	-5.7	.077	-1.2	.037	15	17	45
64	24:34:56	24:34:54	24:34:58	4	.2500	.10576	.44721	[illegible]	[illegible]	-1.7	-5.4	.044	-.7	.047	217	17	45
65	24:35:19	24:35:19	24:35:20	1	1.0000	[illegible]	[illegible]	3125.[illegible]	[illegible]	-1.[illegible]	-5.4	.027	-.7	.014	15	17	45
66	24:35:46	24:35:4[illegible]	24:35:5[illegible]	7	.1429	[illegible]	[illegible]	[illegible]	[illegible]	-1.[illegible]	-5.6	[illegible]	-1.1	[illegible]	127	17	45
67	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ICEDERIV Sample Output (cont'd)

69 25103125 2512138 2 1.4113 ... 633.7 1. ... 1.445 2.6 1.505 0 1 15

RATE LEAST SQUARE FIT LINES

CYCLE NO	JW-LWC AS A FUNC OF RMS-LWC SLOPE	INCEP	CORR	1/RT	AS A FUNC OF JW-LWC SLOPE	INCP	CORR	F(AVE)	AS A FUNC OF JW-SMOOTH SLOPE	INCEP	CORR	F(AVE)	AS A FUNC OF RMS-LWC SLOPE	INCEP	CORR	F(AVE)	AS A FUNC OF RMS-SMOOTH SLOPE	INCEP	CORR	F(AVE)
1	3.4711	-.0314	.362	.027	.26	.17	.0737	.01727	.023	.017	.0635	.01726	-.055	.018	-.0375	.01770	-.074	.018	-.0492	.01732
2	-.0310	-.0624	-.7375	.0025	[illegible]	[illegible]	[illegible]	[illegible]	-.140	-.003	[illegible]	.00006	-.001	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.0772	.00096
3	1.625	.1559	.2265	.0455	.1	.1	.3512	.03637	.123	.16	.3693	.03715	-.284	.150	-.1952	.07605	-.375	.155	-.2170	.03606
4	1.4511	.3277	.7294	.0096	.23	-.00	.4599	.03524	.029	-.005	.4585	.03524	.054	.003	.1364	.07526	.087	.003	.1761	.00525
5	1.7023	.0457	.1316	.040	-.05	.04	-.4414	.03126	-.072	.049	-.4513	.03122	-.049	.134	-.2015	.07115	-.054	.079	-.2080	.03122
6	1.1046	.0310	.8616	.0323	.154	-.011	.5256	.02466	.173	-.013	.5373	.02455	.255	-.019	.6241	.02437	.255	-.024	.6543	.02498
7	.6287	.0521	.6272	.0217	.153	.17	.2137	.01653	.164	.011	.2345	.01646	.164	.012	.2594	.01875	.340	.011	.2662	.01840
8	.7582	.0357	.6966	.0232	[illegible]	[illegible]	.3529	.01193	.137	-.003	.5827	.01192	.171	-.001	.5619	.01170	.272	-.003	.6156	.01195
9	.3713	.0224	.1655	.0227	.165	.016	.5974	.01847	.172	.005	.7113	.01865	.207	.007	.7742	.01895	.220	.006	.7934	.01895
10	.5353	.0786	.7134	.0553	.143	.017	.6122	.04592	.171	.017	.7433	.04527	.141	.022	.6417	.04595	.272	.017	.7762	.04556
11	.5664	.0492	.5526	.0313	.125	.015	.6113	.02865	.139	.014	.6303	.02895	.135	.014	.6441	.02457	.166	.011	.7058	.02887
12	1.1415	-.0135	.7566	.0455	.217	[illegible]	.4643	.03633	.220	-.020	.4683	.03581	.223	.004	.6587	.03577	.245	.001	.6880	.03568
13	1.3461	.0112	.5621	.0195	.271	-.004	.9639	.01274	.277	-.004	.9713	.01281	.394	-.005	.9205	.01277	.424	-.007	.9531	.01292
14	.3331	.0359	.7473	.0625	.235	[illegible]	.6253	.04434	.259	.007	.6505	.04525	.423	-.004	.7893	.04526	.445	-.005	.9127	.04618
15	1.5367	-.0113	.7989	.1423	.134	.030	.3284	.07292	.193	.026	.6535	.07223	.341	.017	.8977	.07342	.378	.011	.9526	.07237
16	.7562	.0932	.5553	.0625	-.138	.157	-.1363	.04215	-.101	.162	-.1643	.04205	-.124	.150	-.1377	.04155	-.172	.167	-.2361	.04185
17	1.1212	.0438	.8137	[illegible]	.432	-.047	.8658	.05766	.434	-.043	.8702	.05705	.574	-.035	.8355	.05215	.692	-.054	.9087	.05549
18	.3625	.0444	.7126	.0714	.234	.001	.8432	.03192	.243	.030	.8540	.03143	.325	.003	.8682	.03065	.356	-.000	.8987	.03077
19	1.1683	.0150	.8676	.0165	.225	-.007	.8902	.01426	.233	-.094	.9017	.01440	.318	-.003	.9577	.01359	.332	-.004	.9747	.01351
20	.7112	.0251	.7878	.0323	.254	[illegible]	.8547	.02518	.290	.010	.8963	.02539	.231	.006	.8267	.02533	.262	[illegible]	.8845	.02563
21	1.1951	.0169	.8238	.0294	.217	-.001	.8163	.01527	.232	-.002	.8263	.01513	.295	-.000	.8228	.01517	.325	-.002	.8576	.01530
22	1.3695	.0138	.3532	.0763	[illegible]	.027	.4439	.04117	.082	.026	.4471	.04101	.162	.021	.5570	.04076	.175	.019	.6024	.04098
23	1.3731	.0700	.9201	.1111	.111	.031	.3971	.04859	.119	.031	.3941	.04821	.263	.020	.5926	.04834	.235	.019	.6221	.04791
24	1.3877	.0213	.7629	.0143	.257	-.003	.7587	.01214	.297	-.005	.7932	.01193	.432	-.002	.7567	.01125	.477	-.003	.8994	.01171
25	1.2346	.0135	.196	.0294	.299	-.001	.9163	.02493	.303	-.002	.9455	.02469	.420	-.002	.8892	.02353	.475	-.005	.9530	.02510
26	1.3733	.0219	.7475	.0783	.208	.011	.7396	.06976	.222	.007	.7617	.06969	.437	-.010	.8377	.06779	.532	-.076	.3290	.06891
27	.6723	.0979	.7521	.0633	-.261	.023	-.4296	.03097	-.339	.038	-.4835	.03184	-.197	.051	-.2668	.03204	-.274	.073	-.3324	.03220
28	1.2844	.0114	.9471	.0400	.242	.002	.9235	.02897	.247	.002	.9325	.02816	.350	.002	.9851	.02996	.368	.001	.9922	.02967
29	1.3526	.0153	.163	.0385	-.32	.17	-.1535	.01364	-.33	.18	-.1575	.01361	.009	.013	.0314	.01357	.016	.013	.0207	.01357
30	.8845	.0893	.7513	.2503	.148	.043	.3655	.07889	.161	.041	.9073	.07856	.186	.047	.9246	.03112	.218	.042	.9996	.08003
31	.4085	.0691	.5303	.0455	.34	.023	.2234	.03152	.128	.020	.2443	.03142	.012	.030	.0647	.03149	.021	.070	.0659	.03148
33	1.2165	.0374	.9117	.0831	.028	.047	.1129	.05188	.033	.047	.1253	.05182	.110	.042	.2655	.05222	.115	.040	.2817	.05122
40	3.5173	.1577	.1556	.1625	.33	.5	.0913	.05550	.37	.153	.974	.05535	-.696	.159	-.1163	.05571	-2.676	.165	-.1788	.05519
41	-2.4934	.1247	-.7277	.0714	.56	.136	.2464	.05335	.136	.038	.2521	.05336	-.017	.157	-.0062	.05336	-.062	.153	-.0192	.05332
42	.5783	-.0020	.3346	.0057	.723	-.001	.8512	-.00157	.356	-.001	.8913	-.00159	-.273	-.001	-.0431	-.00146	-.547	-.001	-.0611	-.00146
43	1.3764	.0417	1.0000	1.0000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000
44	1.1963	.0120	.7565	.100	-.1	.02	-.1393	.01874	-.22	.20	-.1575	.017	-.2	.02	-.152	.01341	-.234	.02	-.1647	.01875
45	.5121	.3975	1.0000	1.0000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.00000
46	2.4441	-.2891	.4060	.50	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000
47	.5923	.2127	1.0000	1.0000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000
48	.3205	.3700	1.0000	1.0000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000
49	-.2591	.7442	-1.0000	1.0000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000
51	-7.7532	3.2613	-1.0000	1.0000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000
52	1.1263	.1452	1.0000	1.0000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000
53	.3365	.5232	1.0000	1.0000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000	0.000	0.0000	.00000	.00000
55	1.7672	-.0595	.3279	.1429	[illegible]	.77	-.1615	.06757	-.26	.77	-.1423	.06764	-.087	.091	-.2617	.06757	[illegible]	.071	-.2517	.06776
56	2.1911	-.1731	.368	.056	[illegible]	.7	[illegible]	.02688	-.91	.72	-.6813	.02666	[illegible]	.166	-.7766	.02622	-.146	.072	-.4030	.02619
57	-.1165	.5059	-.1556	.1111	[illegible]	.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.1577	.04777	-.053	.055	-.4107	.04800
58	-.1269	.3670	-1.0000	1.0000	0.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.00000	.00000	0.000	0.0000	.00000	.00000
59	-.0297	.4240	-.1561	.3333	.288	-.051	.8320	[illegible]	[illegible]	-.051	.0323	.12175	.076	.036	.4053	.10976	.076	.005	.4053	.10976
60	.2046	.3641	[illegible]	[illegible]	-.77	.214	[illegible]	.0659	-.727	.236	-.0233	[illegible]	-.76	.113	-.2894	.07335	[illegible]	.373	-.3526	.08657
61	-1.4337	.8246	[illegible]	.3333	[illegible]	.53	[illegible]	.11791	[illegible]	[illegible]	.3635	.11791	-.714	.175	-.7770	.10437	-.714	.175	-.7720	.10480
62	.2547	.3631	[illegible]	[illegible]	[illegible]	[illegible]	-.3124	[illegible]	[illegible]	[illegible]	-.4704	[illegible]	[illegible]	.217	[illegible]	[illegible]	-.468	.250	-.9006	.08611
63	1.5765	.0602	.104	.5001	0.000	[illegible]	.00000	.00000	0.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.00000
64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ICEDERIV Sample Output (cont'd)

PASS SUMMARY DATA

PASS NO.	START TIME	STOP TIME	TOTAL CYCLES	AV T	T S.DEV.	AV LWC	AVE JW	JW S.DEV.	AV PMS	PMS S.DEV.	PRESS (MB)	PRESS S.DEV.	ALT (M)	TOTAL TEMP	TRUE TEMP	TRUE T S.DEV.	DEWP DEPRE	D DEP S.DEV.	NVD
9	24126107	24135152	23	4	3.933	.6031	.395	.21335	.355	.13567	659.6	.512	3128.5	-1.4	-6.4	.241	-.7	.367	14
	25131159	2516[illegible]113	2	49	45.5[illegible]	.2553	.017	.03679	.000	.00137	671.1	21.798	3321.4	.9	-6.0	1.970	2.5	1.561	0

ICEDERIV Sample Output (cont'd)

2.5.5 Program ICELWC

ICELWC was written to compare ice detector values to the LWC values as derived from the PMS-1D particle sizing system.

ICELWC calculates five different parameters based upon PMS-1D and ice detector values. These calculations are then tabulated with VCO information. A line is printed for every second that the ice detector is in the sensing mode.

A. DEPTH OF ICE

This is the depth of ice that would accumulate on the ice detector if all the water in the ice detector's sampling volume were to form ice. The amount of water is determined by a LWC measurement device.

1. The sample volume for the ice detector is its length (1") times its width (1/4") times velocity times time

   VOLUME(m**3) = 0.0254m*0.0063m*velocity(m/sec)*time(sec)

2. LWC is amount of water per cubic meter (g/m**3)

3. calculate how much water was seen in ice detector sample volume

   ICE(gm) = VOLUME(m**3)*LWC(g/m**3)

4. convert the ice to a volume (density of ice is 9.17E-7 gm/m**3)

   VOLUME(m**3) = ICE(gm)*9.17E-7(g/m**3)

2.5.5 Program ICELWC (cont'd)

5. remove the length and width components from the volume thus giving the depth in m**2

DEPTH(m) = VOLUME(m**3)/(0.0254*0.0063)

B. CHANGE IN DEPTH
DELTA DEPTH = DEPTH(i) - DEPTH(i-1)

C. RATE OF ICE ACCRETION
RATE = (COUNT(i+1) - COUNT(i-1))/2.0

D. CHANGE IN RATE
DELTA RATE = RATE(i) - RATE(i-1)

E. RATIO OF DELTA DEPTH TO DELTA RATIO
RATIO = DELTA DEPTH/DELTA RATE

At the end of every cycle a correlation of DELTA DEPTH vs RATE is calculated. Also reported is the ratio of the difference in counts of the last count in the cycle and the first sensing point divided by the total LWC of the sensing mode. This gives the number of counts per gram of observed water.

The above procedure is repeated using the JW-LWC values instead ot the PMS. Operating instructions appear in the following section.

2.5.5.1 Program ICELWC operating instructions

COMMAND CARDS

```
DPSI,T200,NT1.                    ID#            NAME
ATTACH,LGO,ICELWCBIN,ID=GLASS,MR=1.
VSN,TAPE1=LYCXXX/NT.        (TAPE 2 FROM ICEEX)
REQUEST,TAPE1,E,NT,NORING.
LGO.
7/8/9
```

DATA CARDS

CARD # 1

COL	1-5	LCHAN (LOWEST PMS CHANNEL TO USE - I5 FORMAT)
	6-10	UPCHAN (UPPERMOST PMS CHANNEL TO USE - I5 FORMAT)
	11-15	*IDATE (INDEX TO SCATTER PROBE CALIBRATIONS-I5 FORMAT)
CARDS (2-N+1)		(N PASS CARDS IN TIME INCREASING ORDER)
COL	1-8	IBEG (START TIME IN FORM - HH:MM:SS)
	10-17	IEND (STOP TIME IN FORM -HH:MM:SS)
	21-30	JWADJ (JW OF SET VALUE - F10.0 FORMAT)
*IDATE=		1 CREATION TO 31 JUL 1978
		2 1 AUG 1978 to 22 JUL 1979
		3 23 JUL 1979 to 29 NOV 1979
		4 30 NOV 1979 to 27 APR 1980
		5 28 APR 1980 to 29 DEC 1980
		6 30 DEC 1980 to 8 APR 1981
		7 9 APR 1981 ONWARDS

CYCLE FROM 27 ... TO 73 ... TYPE = RATE

SECOND	DEPTH	DEL DEPTH	LWC	ND	COUNT	RATE	RATIO		
	[illegible]		4.10731E-01	5.55918E+08	6.40 [illegible]E+03			PMS-1D	94.32
1	[illegible]	[illegible]	4.21343E-01	5.53326E+08	6.4423E+03	1.11E+12	-1.84E-08	PMS-1D	94.32
2	[illegible]	[illegible]	4.2198E-01	5.45993E+08	6.5110E+03	1.98E+12	-1.03E-09	PMS-1D	94.32
3	[illegible]	[illegible]	4.2591E-01	5.53379E+08	6.6470E+03	2.87E+12	2.86E-09	PMS-1D	94.32
4	[illegible]	[illegible]	4.17149E-01	5.47116E+08	6.7390E+03	3.09E+12	-1.45E-09	PMS-1D	94.32
5	[illegible]	[illegible]	4.57641E-01	5.52147E+08	6.8490E+03	2.77E+12	-3.91E-09	PMS-1D	94.32
6	[illegible]	[illegible]	3.96993E-01	5.56545E+08	7.0750E+03	2.36E+12	-7.39E-09	PMS-1D	94.32
7	[illegible]	[illegible]	3.82327E-01	5.64309E+08	7.1850E+03	2.11E+12	1.17E-08	PMS-1D	94.32
8	[illegible]	[illegible]	4.18 [illegible]	6.05298E+08	7.2860E+03	2.04E+12	-2.93E-09	PMS-1D	94.32
9	[illegible]	[illegible]	4.12969E-01	5.69377E+08	7.3930E+03	1.39E+12	6.14E-09	PMS-1D	94.32
10	3.4582 12E-05	[illegible]	4.31751E-01	5.74227E+08	7.4950E+03	2.04E+12	5.64E-09	PMS-1D	94.32
11	[illegible]	[illegible]	4.4483 E-01	6.13632E+08	7.5930E+03	1.98E+12	-8.44E-09	PMS-1D	94.32
12	[illegible]	[illegible]	4.2463 [illegible]	6.2 376E+08	7.6930E+03	1.60E+12	-6.77E-11	PMS-1D	94.32
13	[illegible]	-1.15E-06	4.22078E-01	6.21756E+08	7.7530E+03	1.47E+12	-8.21E-09	PMS-1D	94.32
14	3.2965 52E-05	[illegible]	4.1628E-01	6.28844E+08	7.8230E+03	1.20E+12	5.20E-09	PMS-1D	94.32
15	[illegible]	[illegible]	4.2774E-01	6.24440E+08	7.8730E+03	1.45E+12	2.73E-08	PMS-1D	94.32
16	3.0764726E-05	[illegible]	4.56496E-01	6.25332E+08	7.9690E+03	1.90E+12	1.55E-09	PMS-1D	94.32
17	[illegible]	[illegible]	4.6769E-01	6.07345E+08	8.0670E+03	1.95E+12	1.79E-09	PMS-1D	94.32
18	[illegible]	[illegible]	4.62285E-01	6.66644E+08	8.1640E+03	2.00E+12	8.85E-10	PMS-1D	94.32
19	[illegible]	-9.24E-07	4.66237E-01	6.77553E+08	8.2630E+03	2.14E+12	-4.32E-09	PMS-1D	
20	[illegible]	[illegible]	4.46715E-01	6.72289E+08	8.3780E+03	1.90E+12	-9.77E-09	PMS-1D	
21	[illegible]	[illegible]	4.2315E-01	6.65403 [illegible]	8.4530E+03	1.52E+12	-7.77E-09	PMS-1D	
22	[illegible]	-2.17E-07	4.07447E-01	6.56145E+08	8.5300E+03	1.43E+12	-1.52E-09	PMS-1D	
23	[illegible]	[illegible]	[illegible]	6.64767E+08	8.5950E+03	1.38E+12	-5.64E-09	PMS-1D	
24	[illegible]	[illegible]	3.35605E-01	6.52769E+08	8.6680E+03	1.33E+12	-3.67E-09	PMS-1D	
25	[illegible]	[illegible]	3.3812E-01	6.59929E+08	8.7790E+03	1.19E+12	-3.23E-08	PMS-1D	
26	[illegible]	[illegible]	3.43628E-01	6.42889E+08	8.7870E+03	9.60E+11	8.35E-09	PMS-1D	2
27	[illegible]	[illegible]	[illegible]	6.46645E+08	8.3250E+03	1.12E+12	2.67E-08	PMS-1D	94.32
28	[illegible]	[illegible]	[illegible]	6.7736E+08	8.6990E+03	1.57E+12	3.10E-09	PMS-1D	94.32
29	[illegible]	[illegible]	3.55566E-01	6.81690E+08	8.9920E+03	1.54E+12	-1.57E-08	PMS-1D	94.32
30	[illegible]	[illegible]	3.6824 E-01	6.96591E+08	9.0530 E+03	1.21E+12	2.33E-09	PMS-1D	94.32
31	[illegible]	[illegible]	4.1319E-01	6.78898E+08	9.1130E+03	1.15E+12	-1.59E-08	PMS-1D	94.32
32	[illegible]	[illegible]	3.761 1E-01	6.01876E+08	9.1540E+03	9.41E+11	-3.32E-08	PMS-1D	94.32
33	[illegible]	[illegible]	[illegible]	5.94712E+08	9.1970E+03	8.80E+11	7.77E-08	PMS-1D	94.32
34	[illegible]	[illegible]	3.7213E-01	6.7199E+08	9.2470E+03	5.63E+11	4.45E-08	PMS-1D	94.32
35	[illegible]	[illegible]	3.79637E-01	6.71338E+08	9.2530E+03	1.39E+11	-5.55E-08	PMS-1D	94.32
36	[illegible]	[illegible]	3.8421 7E-01	6.26489E+08	9.2550E+03	2.30E+11	8.35E-07	PMS-1D	94.32
37	3.4571383E-05		4.2764E-01	6.26525E+08	9.2550E+03			PMS-1D	94.32

CORRELATION OF CHANGE IN DEPTH TO RATE IS = -1.2355 [illegible]
RATIO OF CHANGE IN COUNTS TO LWC IS = 2.85 [illegible] +13

2.5.5.2 I[illegible]LWC Sample Output

2.5.6 Program PLTEXTRACT

Program PLTEXTRACT produces pen plots which contain icing data on the top half of the paper and two lines of VCO plots on the bottom half. The VCO data is triggered by icing cycles. VCO buffers are filled only when in an icing cycle. The buffers are then plotted and flushed when one-half hour of data has been stored.

PLTEXTRACT was written as a means of verifying the extraction program (see ICEEX). PLTEXTRACT plots the extracted data on the same scale as PLTICE. This enables the PLTEXTRACT to be overlayed on the PLTICE graph and a visual check of the extraction process made.

The usefulness of the *PLTEXTRACT* plot is more than simply data verification. VCO information or various LWC parameters can be plotted at the bottom and LYC scientists can use this information to help them derive empirical relationships.

Operating instructions appear on the following pages.

2.5.6 Program PLEXTRACT (cont'd)

```
CONTROL CARDS
DPSI,CM130000,T200,NT2.             ID #      ID NAME
ATTACH,LGO,PLEXTRACTBIN,ID=GLASS,MR=1.
ATTACH,PEN,NEWOFFPEN,SN=SHARED.
LIBRARY,PEN.
REQUEST,TAPE39,*Q.
VSN,TAPE1=TAPENO/NT.  (ICEEX PRODUCED OUTPUT TAPE)
REQUEST,TAPE1,NT,NORING,E.
*VSN,TAPE2=TAPENO/NT  (KNOLL1D PRODUCED OUTPUT TAPE)
*REQUEST,TAPE2,NT,NORING,E.
LGO.
7/8/9
DATA CARDS
CARD 1
COL  1-10  FLIGHT ID (FLT EXX-XX)
    11-20  FLIGHT DATE (XX-XXX-XX)
CARD 2
COL  1-12  PLOT #1 LITERAL
CARD 3
COL  1-12  PLOT #2 LITERAL
CARD 4     (FREE FORMAT)
PLOT #1    ID NUMBER
PLOT #2    ID NUMBER
PLOT #1    MINIMUM VALUE
PLOT #1    MAXIMUM VALUE
PLOT #2    MINIMUM VALUE
PLOT #2    MAXIMUM VALUE
6/7/8/9
```

2.5.6 Program PLEXTRACT (cont'd)

* OPTIONAL

PLOT ID CODES

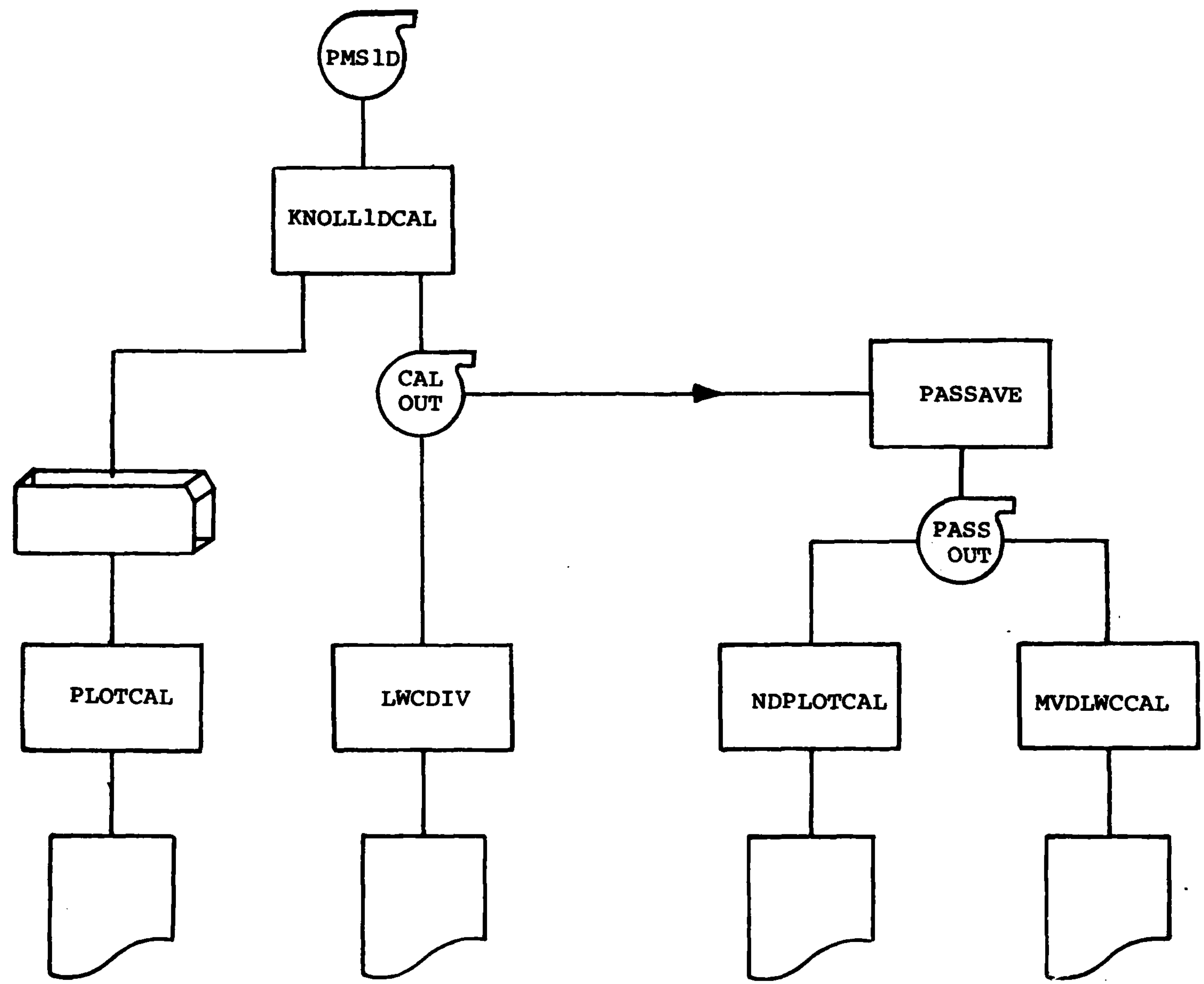
NUMBER	DESCRIPTION	
1	TOTAL TEMPERATURE	(FROM TAPE1)
2	JW-LWC	"
3	TRUE TEMPERATURE	"
4	ASSP PROBE LWC	(FROM TAPE2)
5	CLOUD PROBE LWC	"
6	PRECIP PROBE LWC	"
7	TOTAL PROBE LWC	"
8	LOG ASSP PROBE NT	"
9	LOG CLOUD PROBE NT	"
10	LOG PRECIP PROBE NT	"
11	LOG TOTAL PROBE NT	"
12	ASSP PROBE D0	"
13	CLOUD PROBE D0	"
14	PRECIP PROBE D0	"
15	TOTAL PROBE D0	"
16	ASSP PROBE D0 TIMES LWC	(FROM TAPE2)
17	CLOUD PROBE D0 TIMES LWC	"
18	PRECIP PROBE D0 TIMES LWC	"
19	TOTAL PROBE D0 TIMES LWC	"

2.6 AFFTC spray test

During April and September 1980 the Air Force Flight Test Center (AFFTC) at Edwards Air Force Base conducted a set of nozzle spray tests. These tests consisted of flying the MC130E behind a KC135 tanker and measuring water and ice spray striking the PMS devices mounted on the wings of the MC130E aircraft.

The following is a description of the programs that DPSI developed to help them create a data base. The resultant meteorological data about the size distributions and liquid water content can then be used to design/utilize nozzles to test icing rates on various aircraft.

Figure 2.56: AFFTC Spray Test Program Flow



2.6.1 Program KNOLL1DCAL

Program KNOLL1DCAL is a unique version of KNOLL1D used in the analysis of the spray test data gathered during the KC135 tanker and MC130E aircraft.

Most of the data will fall into the sampling range of the axial scattering probe. This probe is not used in any "total" calculations from the PMS-1D post processing system. This system was designed to provide values in snow situations and the axial device is only accurate in rain studies. Thus, in order to be able to properly analyze the spray test data a special version of KNOLL1D was developed, KNOLL1DCAL.

All "total" values (LWC, Z, MK, NT, D0, and LMAX) include the axial probe. There is inherent sampling overlap between the axial and droplet probes. The upper limit of the axial sampling size is 32 microns, while the lower limit of the droplet probe is 13. To eliminate this problem, channel one of the droplet probe is not used in the "totals" thus raising the droplet lower limit to 33 microns which results in a one micron gap. Additionally, the unnormalized number density was required to show the actual counts per unit of volume (meter cubed) for each discrete class. As a result, the number densities given in the output are not normalized. The format of the output is unchanged from the standard KNOLL1D format.

2.6.1 Program KNOLL1DCAL (cont'd)

There are only a few differences in the operating instructions of KNOLL1DCAL as opposed to the procedures used with the standard KNOLL1D. KNOLL1DCAL does not use the automatic processing of the VCO calibration coefficients. Therefore it is not necessary to attach TAPE8 to the VCOCALS file. The program requies that the proper calibration values be included in the namelist VCOEF contained in the submitted job deck.

All other procedures are the same as outlined in section 2.1.1. An additional output deck is produced by KNOLL1DCAL for use with program PLOTCAL. A description of this deck is outlined below.

NUMBER	PARAMETER
1	TIME IN FORM @HH@MM@SS WHERE @ = BLANK
2	AVERAGING INTERVAL IN SECONDS
3	LWC (IN FORMAT E15.6)
4	D0
5	SEPARATION DISTANCE (F10.0)
6	FLOW RATE (F10.0)
7	BLEED RATE (F10.0)
8	FLIGHT ID (A10)
9	DEWPOINT (F10.0)

Table 2.6: KNOLL1DCAL output 'Deck' (TAPE4)

2.6.2 Program PLOTCAL

Program PLOTCAL is a useful program to graphically determine relationships between various parameters of the AFFTC spray test samples. PLOTCAL uses as data a 9 word record produced by KNOLL1DCAL specifically for this purpose. A description of this record can be found in 2.6.1.

PLOTCAL will accept from input 3 parameters, a plot literal and two integers defining values which are to be compared. A pen plot will be produced for each input card. The relationships are illustrated as a scatter plot, one point for each record produced by KNOLL1DCAL.

2.6.2 Program PLOTCAL (cont'd)

```
   DPSI,T200,CM60000,NT1.           ACT #           NAME
   ATTACH,LGO,PLOTCALBIN,ID=GLASS.
 * VSN,TAPE1=LYCXXXINT.
   REQUEST,TAPE1,E,NORING,NT.
   ATTACH,PEN,ONLINEPEN.
   LIBRARY,PEN.
   REQUEST,PLOT,*Q.
   LDSET,PRESET=ZERO
   LGO
   EXIT(U).
   DISPOSE,PLOT,PL.
   7/8/9

   DATA CARDS (1-N)

** PLOT LITERAL, X AXIS VALUE, Y AXIS VALUE

   6/7/8/9
```

*   KNOLL1DCAL PRODUCED OUTPUT DECK (TAPE4)

** TABLE FOR INPUT RECORD IN SECTION 2.6.1
NOTE: VALUES OF 1, 2, 8 SHOULD NOT BE USED

2.6.3 Program LWCDIV

Program LWCDIV plots the divergence from the mean for a set of LWC data points against a time axis.

LWCDIV is an interactive program designed for use under INTERCOM with either a direct plot to a Tektronix terminal or disposed from a terminal to the microfiche plotter.

Two plot types can be produced, that is, either standard arithmetic or a geometric averaging. Also displayed on the plot, along with the pass data, are the following statistical parameters: mean, standard deviation, set minimum and set maximum.

Operating instructions and sample plot appear on the next page.

2.6.3.1 Program LWCDIV operating instructions

```
LOGIN,ID,ID#,TTY#.
M, PLS MOUNT DISK LYCPFI.
MOUNT, VSN=LYCPFI,SN=LYCPFI.
SETNAME, LYCPFI.
ATTACH,TAPE1,PLTNAME,IDNAME.
REQUEST,TAPE39,*Q.
ATTACH,LGO.LWCDIVBIN,ID=LALLY.
ATTACH,CRT,CRTPLOTS,SN=SHARED
LIBRARY,CRT.
LGO.
```

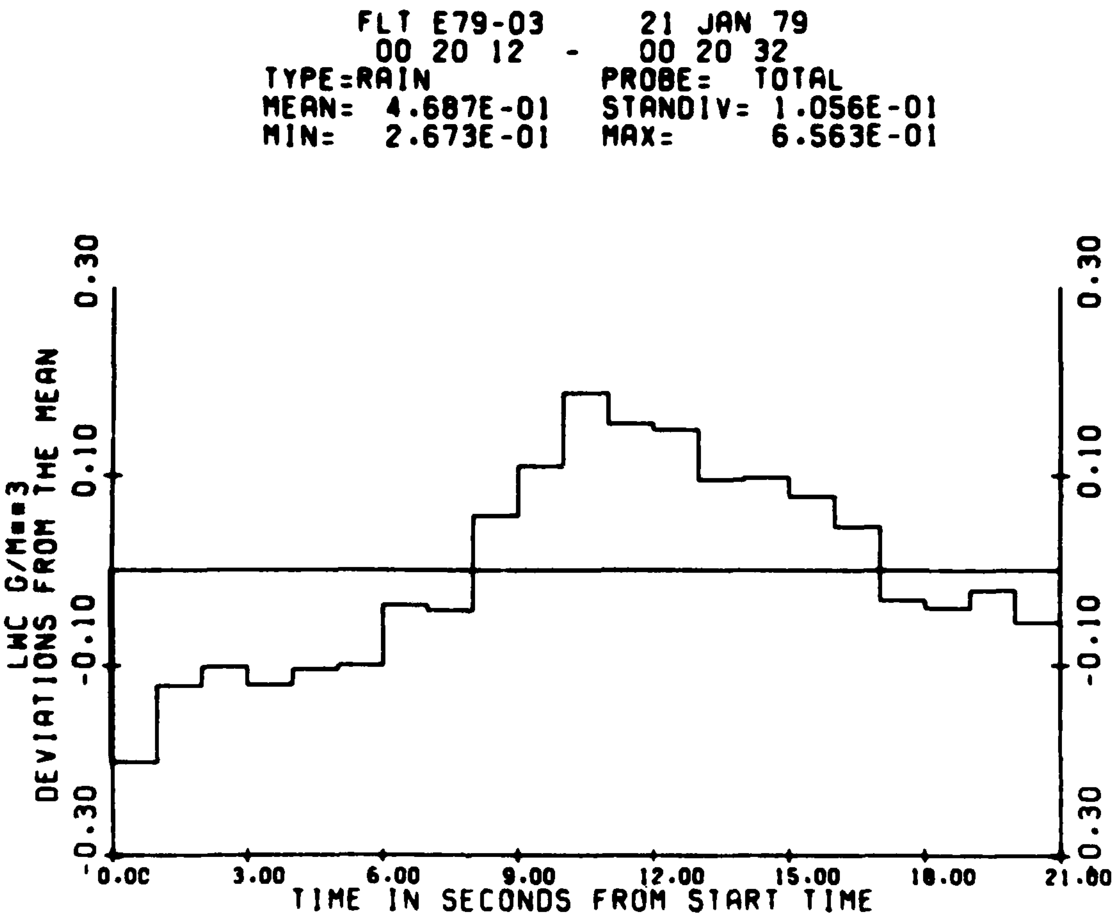
TTY WILL RESPOND WITH FOLLOWING PROMPTS:

```
INPUT CLOCK(1=A/C, 2=PMS)...
INPUT STAT TIME(HH MM SS)...
INPUT TYPE OF AVERAGING(1=ARITH, 2=LOG)....
INPUT LENGTH IN SECONDS OF INTERVAL TO PLOT...
INPUT PROBE(1=SCATTER, 2=CLOUD, 3=PRECIP, 4=TOTAL)...
1=CONT, 2=STOP...
```

AFTER STOPPING TYPE FOLLOWING:

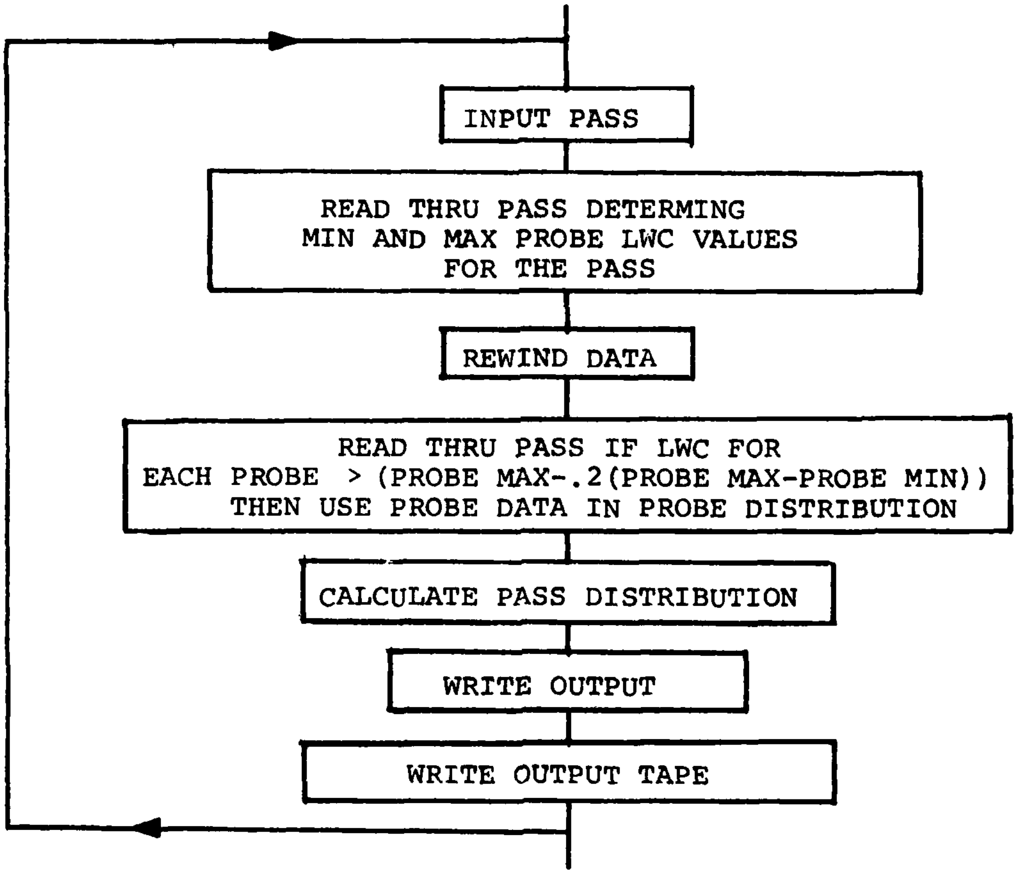
```
DISPOSE,TAPE39,FM.
LOGOUT
```

2.6.3.2 LWCDIV sample output



2.6.4 Program PASSAVE

The AFFTC spray test program requires a full distribution for a given flow and bleed rate as well as separation distance. During a sample run, however, it is impossible to align all three 1D probes in the plume of the spray. A method was designed to give a full average distribution by extracting and using probe data while in the plume. This method is described below.



PASSAVE outputs a total distribution and various meteorological parameters (see the sample output in section 2.6.4.2). An output tape is produced containing the average data.

2.6.4.1 Program PASSAVE operating instructions

```
   DPSI,T400,CM60000,NT2.                  ACT #        NAME
   ATTACH,LGO,PASSAVEBIN,ID=GLASS.
 * VSN,TAPE1=LYCXXX/NT.
   REQUEST,TAPE1,E,NORING,NT.
** REQUEST,TAPE2,N,RING,NT.
   LDSET,PRESET=ZERO.
   LGO.
   EXIT(U)
   REWIND,TAPE3.
   COPY,TAPE3.
   7/8/9

   DATA CARDS 1-N

   col  2-9     START       HH:MM:SS
   col 12-19    STOP        HH:MM:SS
   col 31-40    OUTPUT LITERAL
   col 50       IAS         1 = TRUE AIRSPEED
                            2 = CALCULATED AIRSPEED

   6/7/8/9
```

* KNOLL1DCAL PRODUCED OUTPUT TAPE (TAPE2)

** PASSAVE PRODUCED OUTPUT TAPE (SAME FORMAT AS THE KNOLL1D OUTPUT TAPE)

2.6.4.2 Program PASSAVE sample output

AFFTC SPRAY TEST STUDY BY AFGL

SAMPLE 1

FLT E80-26 ON 18 SEP 80 FROM 17:12:50 TO 17:13:20

H2O FLOW(GPM)	AIR PRESSURE(PSI)	SEPERATION DISTANCE(FT)
15	35	100

PRESSURE(MB)	ALTITUDE(M)	TEMPERATURE(C)	FROSTPOINT(C)	TRUE AIRSPEED(M/S)
437.01	6552.06	-13.79	-22.43	138.14

PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3)

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
3	1.284E+06	23	1.057E+06	350	9.140E+01	
6	4.903E+06	43	4.712E+05	647	4.353E+00	
9	1.558E+07	62	3.198E+05	944	0.	
12	1.405E+07	82	1.968E+05	1241	0.	
15	8.466E+06	102	1.219E+05	1538	0.	
18	5.939E+06	122	8.784E+04	1835	5.377E+00	
21	3.895E+06	142	6.859E+04	2132	0.	
24	2.804E+06	161	3.068E+04	2429	0.	
27	2.072E+06	181	2.472E+04	2726	0.	
30	1.367E+06	201	1.672E+04	3023	0.	
33	1.215E+06	221	1.187E+04	3320	0.	
36	1.063E+06	241	9.888E+03	3617	0.	
39	1.381E+06	260	8.533E+03	3914	0.	
42	1.146E+06	280	4.662E+03	4211	0.	
45	8.701E+05	300	4.448E+03	4508	0.	TOTALS (NO PRECIP)

	SCATTER PROBE	CLOUD PROBE	PRECIP PROBE	TOTALS (NO PRECIP)
LWC(G/M**3)	3.194E-01	9.385E-01	2.011E-02	1.231E+00
Z(MM**6/M**3)	2.595E-02	1.527E+01	2.064E+02	1.529E+01
K(M/Z**.5)	1.983E+00	2.402E-01	1.400E-03	3.148E-01
MED D(MU)	34	176	1813	140

2.6.5 Program MVDLWCCAL

Program MVDLWCCAL, using PASSAVE produced data, will produce a scatter plot of total LWC versus the mean volume diameter, one point for each input record.

An entire flight can be represented on one pen plot, making an overall analysis of the flight possible. Beside each point is an integer (1-9) representing a given combination of aircraft separation, flow and bleed rate at that time. The exact combination is defined as follows:

Table 2.7: MVDLWCCAL table

VALUE	SEPARATION	FLOWRATE
1	100	7
2	100	10
3	100	15
4	200	7
5	200	10
6	200	15
7	300	7
8	300	10
9	300	15

Operating instructions appear on the following page.

2.6.5 Program MVDLWCCAL (cont'd)

Operating instructions

```
  DPSI,T200,CM60000,NT1.                  ACT #          NAME
  ATTACH,LGO,MVDLWCBIN,ID=GLASS.
* VSN,TAPE1=LYCXXX/NT.
  REQUEST,TAPE1,E,NORING,NT.
  ATTACH,PEN,ONLINEPEN.
  LIBRARY,PEN.
  REQUEST,PLOT,*Q.
  LDSET,PRESET=ZERO.
  LGO.
  EXIT(U).
  DISPOSE,PLOT,PL.

  6/7/8/9
```

* PASSAVE PRODUCED DATA TAPE (TAPE2)

2.6.6 Program NDPLOTCAL

Program NDPLOTCAL takes the data tape produced by PASSAVE and makes one plot for every record of the tape. The plot produced is the log normalized number densities versus channel diameters. The plot is done using only the data of the scatter and cloud probes. An example of this plot can be found in section 2.6.6.2.

All processing is done automatically, with one exception. A record in A10 format is read from input for each record on the data tape. This contains the sample literal which is printed at the top of the plot. Also displayed at the top of the plot are flight date and number as well as sampling period start and stop times.

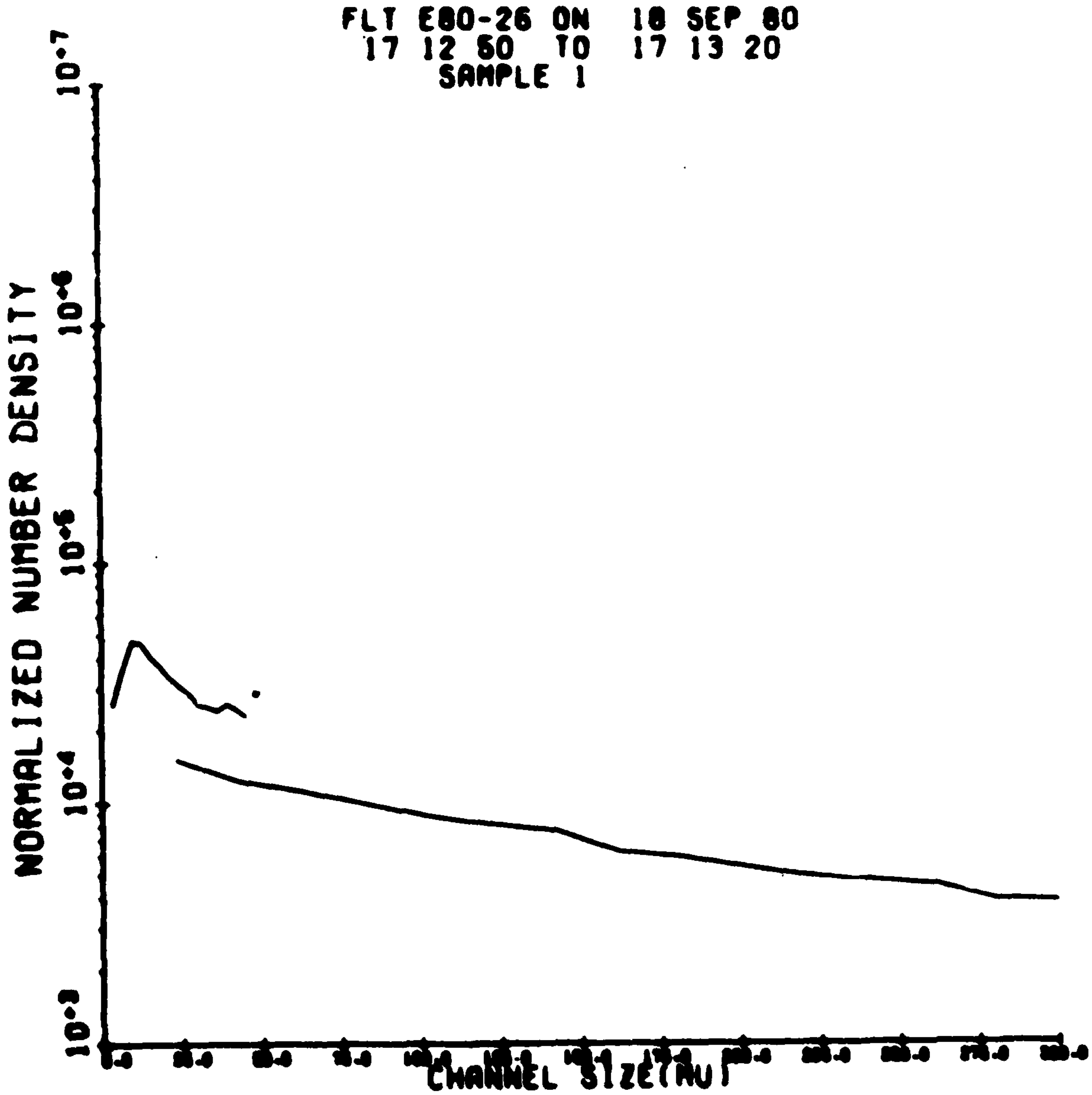
2.6.6.1 Program NDPLOTCAL operating instructions

```
   DPSI,T200,CM60000,NT1.               ACT #          NAME
   ATTACH,LGO,NDPLOTCALBIN,ID=GLASS.
 * VSN,TAPE1=LYCXXX/NT.
   REQUEST,TAPE1,E,NORING,NT.
   ATTACH,CRT,CRTPLOTS.
   LIBRARY,CRT.
   REQUEST,TAPE39,*Q.
   LDSET,PRESET=ZERO.
   LGO.
   EXTI(U).
   DISPOSE,TAPE39,FM.

   7/8/9/

** DATA CARDS (1-N)

   col 1-10    PLOT LITERAL

   6/7/8/9
```

* PASSAVE PRODUCED OUTPUT TAPE (TAPE2)

** INPUT A LITERAL FOR EACH PLOT PRODUCED. PLOTS ARE PRODUCED UNTIL DATA CARDS OR AVERAGED RECORD ARE EXHAUSTED. PLEASE NOTE THESE LITERALS MUST APPEAR IN THE SAME ORDER AS THE OUTPUT PRODUCED BY PASSAVE.

2.6.6.2 Program NDPLOTCAL sample plot



2.7 Miscellaneous programming

2.7.1 Program HIAC1D (Learjet interface to the 1D system)

Pre-processing of Learjet data is done by another contractor. Cloud Physics branch receives a preprocessed 9-track tape of calculated parameters. To make this data available to the 1D processing stream program HIAC1D is run.

HIAC1D takes this 9-track tape and produces an output and output tape identical to those of KNOLL1D. Whatever parameters that are not provided are derived by HIAC1D.

The use of this program makes it unnecessary to include redundant code in the 1D processing system programs. HIAC1D operating instructions appear in the following section.

2.7.1.1 Program HIAC1D operating instructions

```
LALH1,CM50000,T400,NT2.*                ACT#        NAME
ATTACH,LGO,HIAC1DBIN,ID=GLASS,MR=1.
VSN,TAPE1=TAPENO/NT.
REQUEST,TAPE1,PE,L,NR,NT.
VSN,TAPE2=TAPENO/NT.**
REQUEST,TAPE2,RING,NT,N.**
FILE(TAPE1,RT=U,BT=K,MRL=1150,MBL=1150,RB=1,BFS=120)
MAP,OFF.
LDSET,FILES=TAPE1,PRESET=ZERO.
LGO.
EXIT(U)
REWIND,TAPE3,TAPE9.
COPY,TAPE3.
COPY,TAPE9.
7/8/9

-DATA CARDS-
6/7/8/9
```

* IF NO OUTPUT TAPE IS DESIRED CHANGE THE NT2 TO NT1.

** IF NO OUTPUT TAPE IS DESIRED REMOVE THESE CARDS.

NOTE: TAPE2 IS FORMATTED THE SAME AS TAPE2 OF KNOLL1D

```
CARD 1    HEADER CARD
COL  1-6       FLIGHT ID
COL  9-10      NUMBER OF END OF FILES TO SKIP BEFORE PROCESSING
COL 15         = 0 NO INTERPOLATION
               =1  INTERPOLATION
```

2.7.1.1 Program HIAC1D operating instructions (cont'd)

COL 20	= 0 NORMAL OUTPUT	
	= 1 NO STANDARD OUTPUT FILE	
COL 25	= 1 CA DERIVED INPUT TAPE	
	= 2 HP DERIVED TAPE	
	= 3 IBM DERIVED TAPE	

CARDS 2-(N+1)	(N PASSES)
COL 2-9	START TIME HH:MM:SS
COL 12-19	STOP TIME HH:MM:SS
COL 23-25	PASS NUMBER (INTEGER FIELD)
COL 26-30	AVERAGING INTERVAL (INTEGER FIELD)
COL 33	FIRST PROBE TO BE EDITED
COL 34	SECOND PROBE TO BE EDITED
COL 35	THIRD PROBE TO BE EDITED
COL 36-37	CHANNEL TO BE EDITED
COL 38-39	NEXT CHANNEL TO BE EDITED
*	
*	
*	
COL 62-63	N-1 CHANNEL TO BE EDITED
COL 64-65	N CHANNEL TO BE EDITED

2.7.1.2 HIAC1D Sample Output

HIAC1D sample output on the following two pages.

```
IDENTIFICATION: ANT-II
NUMBER OF FILES TO SKIP: 0
INTERPOLATION: ON
OUTPUT OPTION: OFF
FORMAT OF THE INPUT TAPE: C. AUTOMAT
```

START	STOP	PASS	AVE INTERVAL
[illegible]	[illegible]	[illegible]	1
06:23:17	06:25:12	11	1
[illegible]	[illegible]	[illegible]	1
06:31:18	06:34:45	21	1
[illegible]	[illegible]	4	1
07:13:49	07:15:28	5	1
[illegible]	[illegible]	1	1
08:54:28	08:57:52	4	1
[illegible]	[illegible]	5	1
09:14:03	09:18:22	6	1
[illegible]	[illegible]	7	1
09:4?:53	09:46:57	8	1

HIAClD Sample Output

START [illegible] STOP [illegible] ANT-II TOTAL LWC 7.2[illegible]E-01 GM/M**3 TAS 177.[illegible] M/SEC PRES 240.19 MB WIND SPD [illegible] M/SEC
[illegible] [illegible] 04 JUL 78 TOTAL Z 1.6959E+01 M**6/M**3 ALT 11.26 KM TEMP -41.40 DEG C WIND DRC [illegible] DEG
TOTAL DJ 172.25 MICRONS MAG H [illegible] DEG DEWP -33.04 DEG C LATITUDE [illegible] DEG
PARTICLE TYPE(S) (FIXED) AVERAGE TOTAL NT 1.5427E+06 NO/M**3 JW-LWC [illegible] GM/M3 TWCI 0.00 GM/M3 LONGITUD [illegible] DEG
RAIN/SMALL SNOW/SMALL SNOW 1 SECOND TOTAL MK 1.6602E+12 FORM = 2.5[illegible]E-01
INTERPOLATED CHANNELS INDICATED BY A ^

CL	DIAMETER MICRONS	TOTAL COUNTS	NM-DENSITY NO/M**3-MM	LWC GM/M**3	DIAMETER MICRONS	TOTAL COUNTS	NM-DENSITY NO/M**3-MM	LWC GM/M**3	DIAMETER MICRONS	TOTAL COUNTS	NM-DENSITY NO/M**3-MM	LWC GM/M**3
1	[illegible]	73	6.12[illegible]E+08	3.309E-06	23.5	207	1.796E+08	1.789E-02	186.0^	2663	1.099E+06	4.453E-02
2	[illegible]	[illegible]	4.25[illegible]E+09	1.873E-04	38.2	214	5.120E+07	2.089E-02	231.2	1303	2.813E+05	1.424E-01
3	[illegible]	1245	9.51[illegible]E+09	1.411E-03	51.4	192	2.343E+07	2.138E-02	298.6	293	1.046E+05	9.314E-02
4	7.[illegible]	[illegible]	[illegible]	3.6[illegible]E-03	63.8	134	1.030E+07	1.689E-02	355.0	99	2.463E+04	3.466E-02
5	[illegible]	1191	9.376E+09	6.236E-03	75.5	135	7.355E+06	1.932E-02	414.8	20	9.477E+03	1.914E-02
6	[illegible]	7[illegible]	[illegible].639E+09	6.595E-03	86.7	132	5.499E+06	2.072E-02	467.1	2	1.065E+03	2.894E-03
7	1[illegible].6	524	[illegible].997E+09	7.528E-03	97.6	118	3.966E+06	2.058E-02	516.7	4	2.379E+03	8.322E-03
8	[illegible]	[illegible]	2.72[illegible]E+09	7.678E-03	106.1	84	2.490E+06	1.736E-02	564.0	0	0.	0.
9	[illegible]	254	1.316E+09	7.756E-03	115.3	73	2.378E+06	2.084E-02	609.4	0	0.	0.
10	[illegible]	[illegible]	[illegible]	7.540E-03	128.3	75	2.691E+06	2.940E-02	653.2	0	0.	0.
11	19.3	122	9.237E+08	6.9[illegible]2E-03	138.1	54	2.143E+06	2.859E-02	695.7	0	0.	0.
12	[illegible]	[illegible]	7.949E+08	7.455E-03	147.7	52	2.294E+06	3.673E-02	736.9	0	0.	0.
13	[illegible]	[illegible]	6.554E+08	7.914E-03	157.1^	47	2.136E+06	4.048E-02	776.9	0	0.	0.
14	[illegible]	57	5.106E+08	7.701E-03	165.3^	35	1.992E+06	4.412E-02	816.0	0	0.	0.
15	27.[illegible]	53	4.5[illegible]E+08	8.976E-03	175.5^	27	1.513E+06	3.911E-02	854.2	0	0.	0.

TOTAL [illegible] 8.742E-02 TOTAL 1579 3.936E-01 TOTAL 4058 3.451E-01
MK= [illegible] MK= 2.9503E+02 MK= 8.3931E+01
D = 17.7 UN= 4.484E+07 Z= 1.255E-03 DU= 13[illegible].6 UN= 4.144E+06 Z= 1.7[illegible]E+0[illegible] DO= 262.4 UN= 4.403E+04 Z= 1.707E+01
(MICRONS) (NO/M**3) (MM**6/M**3) (MICRONS) (NO/M**3) (MM**6/M**3) (MICRONS) (NO/M**3) (MM**6/M**3)
//

START STOP ANT-II TOTAL LWC 6.7759E-01 GM/M**3 TAS 177.74 M/SEC PRES 240.19 MB WIND SPD 0.00 M/SEC
[illegible] [illegible] 04 JUL 78 TOTAL Z 1.7330E+01 M**6/M**3 ALT 11.26 KM TEMP -41.40 DEG C WIND DRC 0.00 DEG
TOTAL DJ 177.38 MICRONS MAG H [illegible] DEG DEWP -33.10 DEG C LATITUDE 0.00 DEG
PARTICLE TYPE(S) (FIXED) AVERAGE TOTAL NT 1.3895E+06 NO/M**3 JW-LWC [illegible] GM/M3 TWCI 0.00 GM/M3 LONGITUD 0.00 DEG
RAIN/SMALL SNOW/SMALL SNOW 1 SECOND TOTAL MK 1.6415E+12 FORM = 2.660E-01
INTERPOLATED CHANNELS INDICATED BY A ^

CL	DIAMETER MICRONS	TOTAL COUNTS	NM-DENSITY NO/M**3-MM	LWC GM/M**3	DIAMETER MICRONS	TOTAL COUNTS	NM-DENSITY NO/M**3-MM	LWC GM/M**3	DIAMETER MICRONS	TOTAL COUNTS	NM-DENSITY NO/M**3-MM	LWC GM/M**3
1	[illegible]	37	5.532E+08	3.646E-06	23.5	19[illegible]	1.589E+08	1.532E-02	186.0^	2639	9.79[illegible]E+05	3.949E-02
2	[illegible].6	5[illegible]	4.452E+09	1.955E-04	38.2	198	4.739E+07	1.934E-02	231.2	1066	2.991E+05	1.514E-01
3	[illegible]	12[illegible]	9.39[illegible]E+09	1.[illegible]94E-03	51.4	134	1.636E+07	1.493E-02	298.6	279	9.921E+04	8.030E-02
4	7.2	13[illegible]1	9.91[illegible]E+09	3.489E-03	63.8	150	1.153E+07	1.687E-02	355.0	76	3.174E+04	4.469E-02
5	[illegible]	[illegible]	[illegible]	6.[illegible]71E-03	75.5	139	7.579E+06	1.959E-02	414.8	19	9.007E+03	1.819E-02
6	[illegible]	7[illegible]	5.736E+09	6.833E-03	86.7	104	4.334E+06	1.633E-02	467.1	2	1.065E+03	2.895E-03
7	[illegible]	[illegible]	4.379E+09	7.689E-03	97.6	109	3.665E+06	1.912E-02	516.7	0	0.	0.
8	14.[illegible]	354	2.699E+09	7.595E-03	108.1	101	2.995E+06	2.052E-02	564.0	0	0.	0.
9	15.[illegible]	[illegible]	1.516E+09	6.476E-03	118.3	56	2.072E+06	2.456E-02	609.4	0	0.	0.
10	[illegible]	136	1.[illegible]37E+09	5.699E-03	128.3	63	2.261E+06	2.471E-02	653.2	0	0.	0.
11	19.3	[illegible]	[illegible]	5.137E-03	138.1	52	2.461E+06	3.234E-02	695.7	0	0.	0.
12	21.6	1[illegible]5	[illegible].985E+08	7.603E-03	147.7	37	1.456E+06	2.032E-02	736.9	0	0.	0.
13	23.[illegible]	[illegible]	5.799E+08	7.365E-03	157.1^						[illegible]	0.
14	25.2	55	4.193E+08	6.324E-03	166.3^						[illegible]	0.
15	27.	[illegible]	4.117E+08	7.637E-03	175.5^	22	1.2[illegible]E+06	[illegible]		[illegible]	0.	0.

TOTAL [illegible] 7.556E-02 TOTAL 1451 3.484E-01 TOTAL 4077 3.457E-01
MK= [illegible] MK= 2.847[illegible]E+02 MK= 8.7524E+01
D = [illegible] UN= 3.2[illegible]E+07 Z= 1.1[illegible]E-03 DU= 125.4 UN= 3.586E+06 Z= 1.437E+07 DO= 262.[illegible] UN= 4.385E+04 Z= 1.554E+01
(MICRONS) (NO/M**3) (MM**6/M**3) (MICRONS) (NO/M**3) (MM**6/M**3) (MICRONS) (NO/M**3) (MM**6/M**3)

HIAC1D Sample Output (cont'd)

2.7.2 Program FILTER

Persistance in data (non-independence) has always created speculation on the validity of collected meteorological data. Using a method similar to an application in communication (improving signal-to-noise ratios), a power spectrum of the data can be found using a finite Fourier series. Basically this involves subtracting the mean value from each individual data point. The power spectrum of the deviations about the mean are compared with that of white noise (a white noise spectrum is the result of completely independent fluctuations).

Program FILTER uses as data the standard KNOLL1D plot tape. Accepting from input any number of ascending order pass times the total LWC values are stripped off, taking a maximum of 600 points. For each interval 4 plots are produced: centered LWC values, autocorrelation coefficients, unfiltered power spectra, and filtered power spectra. Sample plots can be found in section 2.7.2.2.

The first plot, centered LWC values, plots every pass point along a distance in kilometers and a parallel time axis. The range of the y-axis is input before each pass time to allow for data expansion. A header, repeated for all four plots, is displayed at the top of the plot and contains information necessary for proper data evaluation.

The remaining three plots are defined by their respective equations below. In all three plots the number of points displayed is equal to 1/10th the original number of data points. The autocorrelation plot is placed along an axis

2.7.2 program FILTER (cont'd)

identical to the first plot, however only 1/10th the range. The axis for the power spectra, cycles per kilometer, is determined by considering every two points

An expected autocorrelation plot would start about .9, descending rapidly along the x-axis. If the data was truly independent the unfiltered power spectra would resemble an exponential curve (white noise). The filtered power spectra is determined by factoring the unfiltered by a reciprocal red noise spectra. The resulting graph would indicate any increased higher frequencies in power by a spike in the plot.

The equations used in the calculations are outlined on the following page.

2.7.2 Program FILTER (cont'd)

Equations

1) Mean $= \dfrac{\sum_{i=1}^{npts} x_i}{N}$

2) Variance $= \dfrac{\sum_{i=1}^{npts} x^2{}_i}{Npts}$

3) $Autoco_N = \dfrac{\sum_{i=1}^{npts-1} x_i x_i+n}{(npts-n)\,variance}$

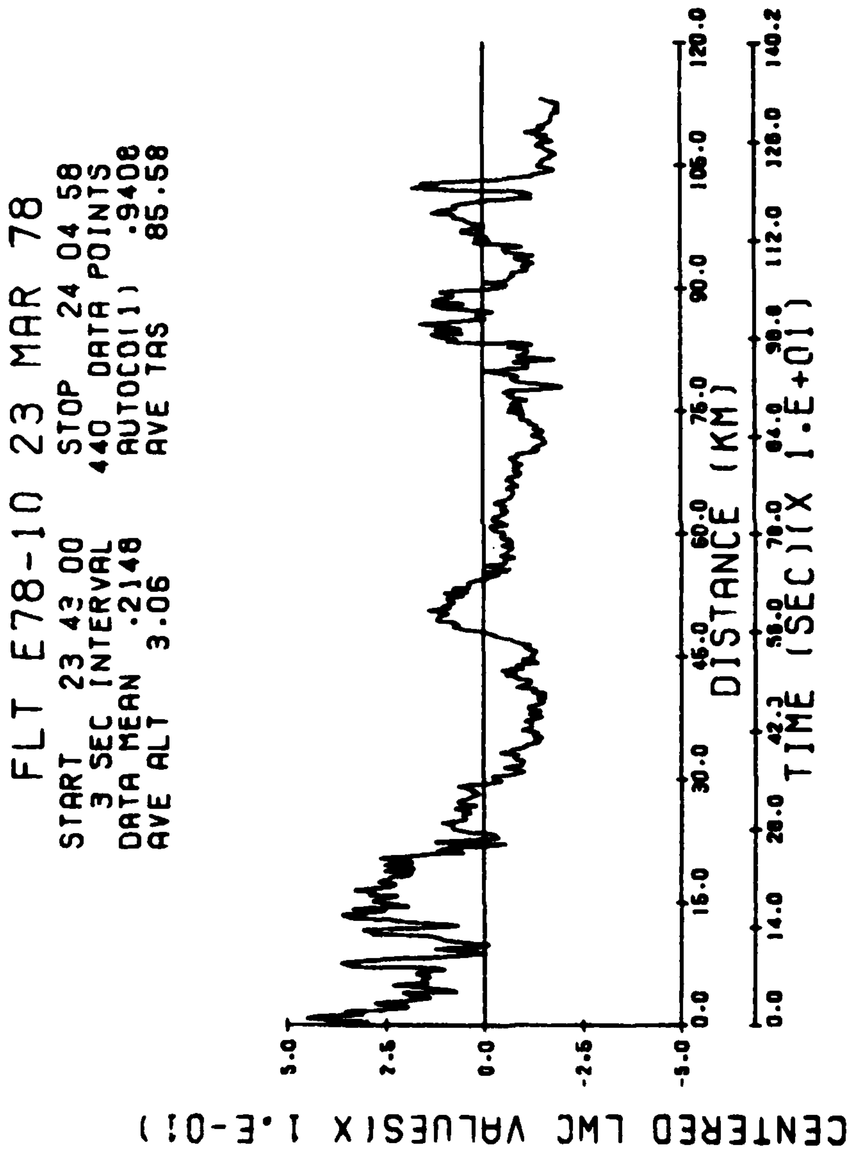
4) $Unfiltered_N = 1 + 2\left[\sum_{i=1}^{nlog-1} Autoco_N Cos(iN\pi)\right] + Autoco_{nlog} Cos(n\pi)$

5) $Filtered_N = Unfiltered_N \left[\dfrac{1+Autoco_1^2 - 2Autoco_1 cos(\frac{N\pi}{nlog})}{1-Autoco_1^2}\right]$

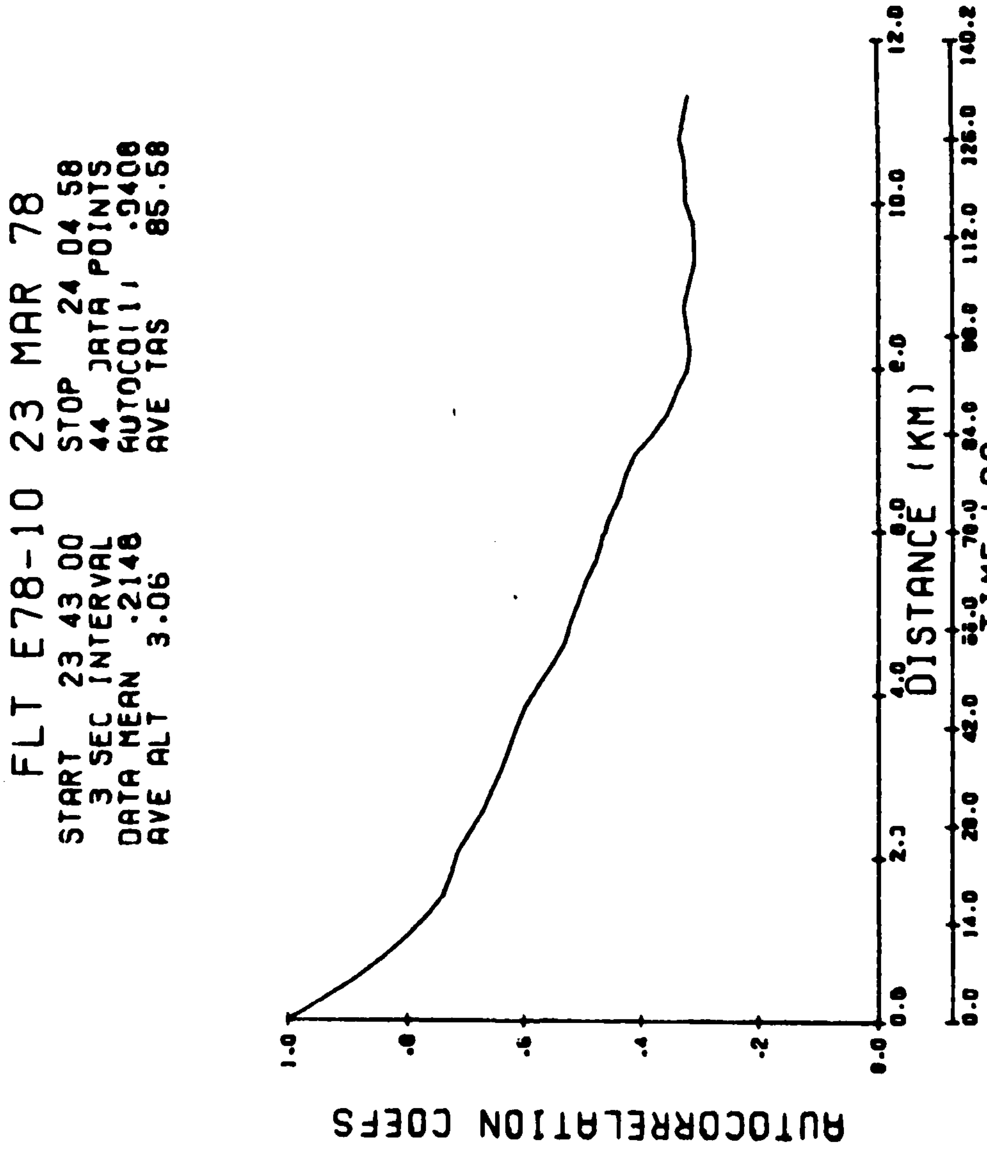
2.7.2.1 Program FILTER operating instructions

```
 DPSI,CM65000,T45,NT1.
 ATTACH,LGO,FILTERBIN,ID=GLASS,MR=1.      ACCT. #     NAME
*VSN,TAPE1=LYCXXX/NT.
 REQUEST,TAPE1,E,NORING,NT.
 ATTACH,CRT,CRTPLOTS.
 LIBRARY,CRT.
 REQUEST,TAPE39,*Q
 LDSET,PRESET=ZERO.
 LGO.
 EXIT(U)
 DISPOSE,TAPE39,FM.
 7/8/9

 DATA CARDS

 CARD #1 (REQUIRED)
 ZMIN,ZMAX (FREE FORMAT)
      ZMIN-MINIMUM PLOT LIMIT FOR CENTERED LWC VALUES
      ZMAX-MAXIMUM PLOT LIMIT FOR CENTERED LWC VALUES

 CARDS 2-(N+1)  (N PASSES IN ASCENDING TIME ORDER)

 HH:MM:SS   COL 1-8  PASS START TIME
 HH:MM:SS   COL 10-17  PASS STOP TIME

 6/7/8/9

 *KNOLL1D PRODUCED OUTPUT TAPE
```

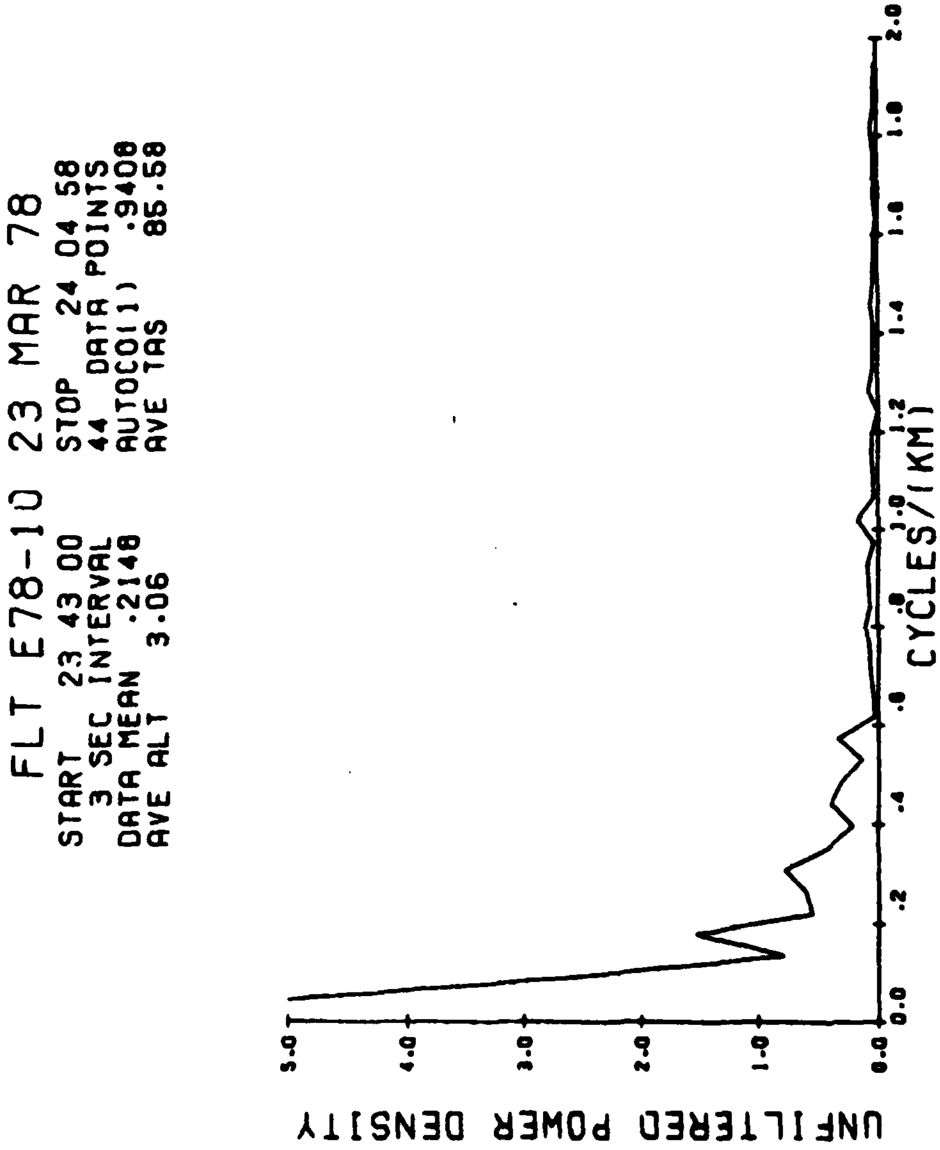
2.7.2.2 Program FILTER sample plots



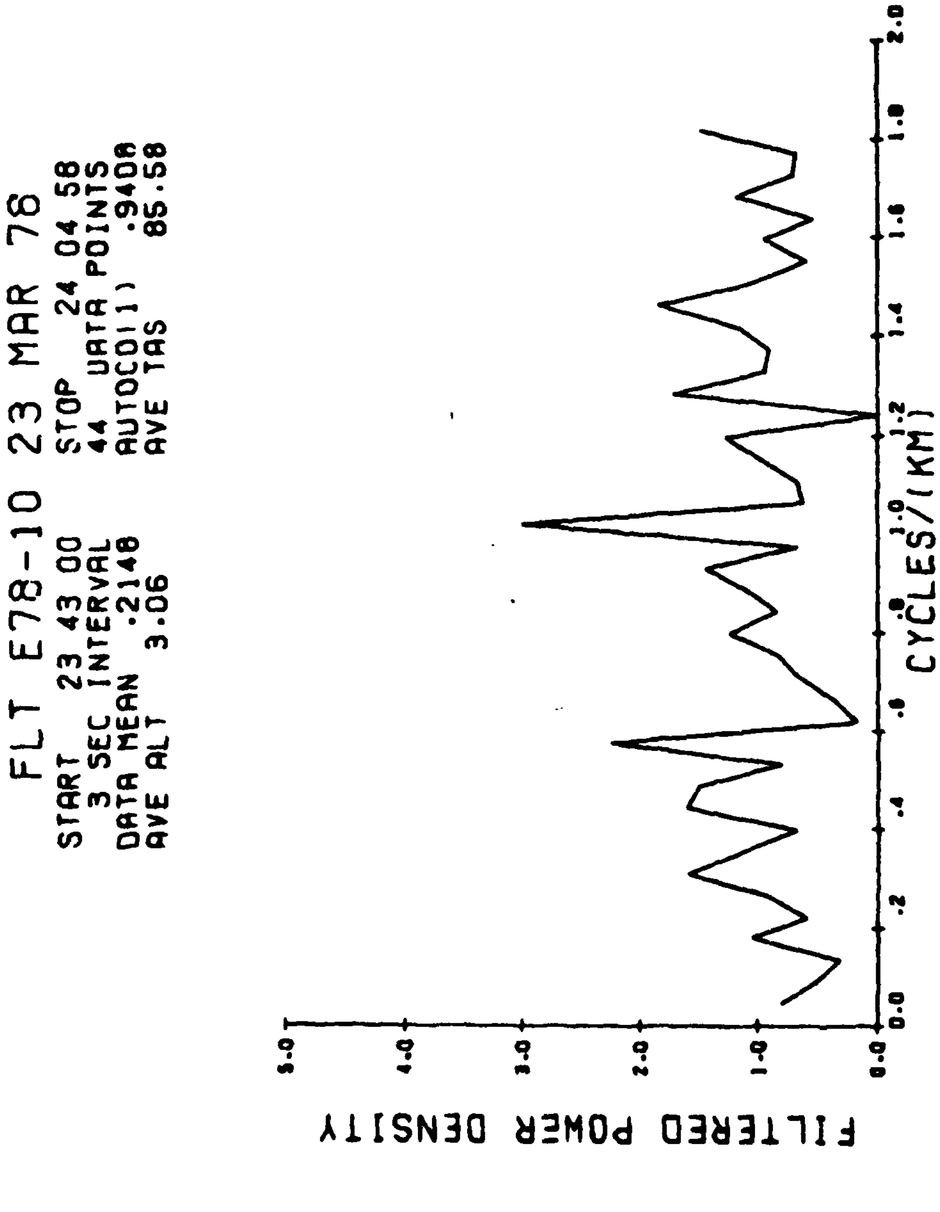
2.7.2.2 Program FILTER sample plots (cont'd)



2.7.2.2 Program FILTER sample plots (cont'd)



2.7.2.2 Program FILTER sample plots (cont'd)



2.7.3 Program FLTPMS

FLTPMS was written to produce a replacement for the PMS-1D tape (should one be needed). It does so by reading an RTX/8 TU-10 flight tape, reformatting the data to be compatible with KNOLL1D, and writing the reformatted data onto a new tape. It is commonly run in batch mode.

FLTPMS requires an RTX/8 TU-10 flight tape as its input tape. The format for this is shown in Appendix 15

The output tape produced has the same format as a PMS-1D data tape (see appendix 2).

Program FLTPMS operating instructions

```
JOBNM,TP2,CM65000,T100.             PROB NO.      NAME
REQUEST,TAPE1,S,HI,MT,RING,VSN=TAPENO1.  (KENNEDY TAPE)
REQUEST,TAPE3,MT,S,VSN=TPAENO3.   (FROM RTX/8)
ATTACH,LGO,FLTPMSBIN,ID=GLASS,MR=1.
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
FILE(TAPE3,RT=U,BT=K,MRL=1135,MBL=1135,RB=1,BFS=116)
LDSET,FILES=TAPE1/TAPE3,PRESET=ZERO.
LGO.
7/8/9
6/7/8/9
```

2.7.4 Program PLTD0

Program PLTD0 was written to read the PMS tape and plot $N*D_o^4/M$ versus D/D_o. Where:

N is normalized number density (NUMBER/M**3/MM)

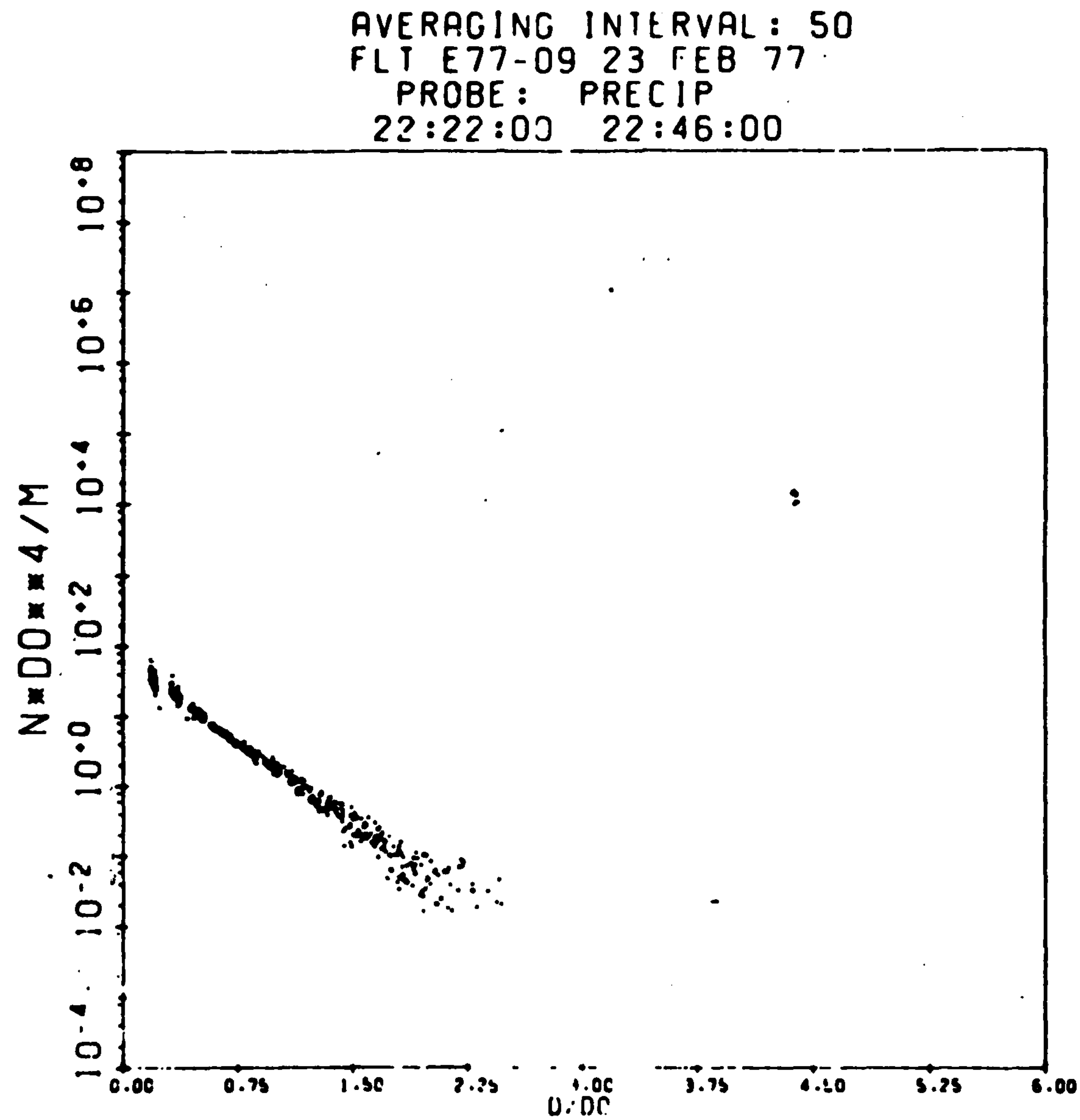
D_0 is the median volume diameter (in MM)

M is the liquid water content (in MG/M**3)

D is the equivalent melted diameter (in MM)

PLTD0 is run interactively using INTERCOM. It produces a microfiche plot. This program duplicates one of the many plots produced by KNPLT1D which cannot run interactively because of central memory requirements.

2.7.4.1 PLOTDO sample plot



2.7.4.2 PLTD0 operating instructions

```
LOGIN,NAME,PASSWORD,861XXXX,SUP
ATTACH,CRT,CRTPLOTS.
LIBRARY(CRT)
REQUEST,TAPE39,*Q
DISPOSE,TAPE39,*FM
ATTACH,LGO,PLTD0BIN,ID=GLASS,MR=1.
ATTACH,TAPE1,KNOLL1DTAPE,ID=NAME,MR=1.
LGO.

ANSWER QUESTIONS ABOUT START AND STOP TIME

REWIND,TAPE2
COPY,TAPE2
LOGOUT
```

2.7.5 ᵀ ˜gram VHPLOT

Program VHPLOT produces calibrated pen plots of reflected PMS-1D VCO and status word data as read from the Kennedy tape. Since any set of five different VCO/STATUS values can be plotted on one frame, and one frame may have up to one hour's worth of data, this program may be used to visually demonstrate the error of one piece of equipment in relation to others.

Input to VHPLOT is via cards through the CDC 6600 batch processor and the input tape is the same as the one used in KNOLL1D and KN1UTIL. Output consists of both tabulated data and CALCOMP pen plots. Plot output may also be routed to the Tektronix graphics terminal.

2.7.5.1 Program VHPLOT operating instructions

CONTROL CARDS

```
JOB,CM60000,T200[1],TP1.                ACT.      NAME
REQUEST,TAPE1,S,HI,VSN=PMSXXX.
ATTACH,LGO,VHPLOTBIN,ID=GLASS,MR=1.
ATTACH,PEN,ONLINEPEN,MR=1.
DISPOSE,PLOT,*OL.
MAP,PART.
FILE(TAPE1,RT=U,BT=K,MRL=1024,MBL=1024,RB=1,BFS=105)
LIBRARY(PEN)
LDSET,FILES=TAPE1,PRESET=ZERO.
LGO.
7/8/9
DATA CARDS
6/7/8/9
```

[1] ALLOW APPROXIMATELY 60 sec/hour/frame

2.7.5.1 Program VHPLOT operating instructions (cont'd)

Data Cards

CARD	CC	DESCRIPTION
1	1	aircraft model A or E
2	2-10	$ CHANGES — CALIBRATION CARDS* INSERTED HERE AS REQUIRED
3	2-6	$ END
4 through (n+3)		for n frames (MAXIMUM ONE HOUR DATA PER FRAME) (CARDS MAY BE IN ANY TIME SEQUENCE)
	1-6	START TIME HHMMSS
	8-13	STOP TIME HHMMSS
	25	PLOT ONE TYPE**
	29-30	PLOT ONE CODE
	35	PLOT TWO TYPE**
	39-40	PLOT TWO CODE
	45	PLOT THREE TYPE**
	49-50	PLOT THREE CODE
	55	PLOT FOUR TYPE**
	59-60	PLOT FOUR CODE
	65	PLOT FIVE TYPE**
	69-70	PLOT FIVE CODE

* CALIBRATION CONSTANTS AND AXIS LIMITS (IN COUNTS) CAN BE CHANGED

** TYPE SPECIFIES WHETHER A PLOT WILL BE V (FOR VCO) OR H (FOR HOUSEKEEPING), THE CODES ARE ON THE FOLLOWING 3 PAGES

2.7.5.1 Program VHPLOT operating instructions (cont'd)

CALIBRATION CARDS

There are three control variables that may be used with the $CHANGES namelist input. The variables shown below allow the calibration coefficients and axis limits to be changed as needed.

VCOA(I,J) controls any changes pertinent to the MC130A VCO's

VCOE(I,J) controls any changes pertinent to the MC130E VCO's

HSVL(I,J) controls any changes pertinent to the housekeeping data for either aircraft

I = 1 specifies calibration intercept
= 2 specifies calibration slope
= 3 specifies minimum counts
= 4 specifies maximum counts

J = 1-13 for A model VCO's
= 1-9 for E model VCO's
= 1-30 for housekeeping data - from the PMS-1D status word code

2.7.5.1 Program VHPLOT operating instructions (cont'd)

PMS 1D VCO CODE

C130A	J	C130E
Pressure	1	Δ P
Δ P	2	Temp
Mag Head	3	EWER
Temp	4	UNUSED
Event/Cloud	5	Dewp/1011
LWC/JW	6	LWC/JW
Rain	7	Mag Head
Tacan Bearing	8	Pressure
Tacan Distance	9	true airspeed
Acceleration	10	
Dewp/1011	11	
Ice	12	
Pitch	13	

PMS 1D STATUS WORD CODE

msec	CODE J	scatter probe status	CODE J	cloud probe status	CODE J	precip probe status
0	1	+15v. supply voltage	2	+15v. supply voltage	3	+15v. supply voltage
1	4	probe temp.	5	mirror temp.	6	mirror temp.
2	7	size range selected	8	element 1 voltage	9	element 1 voltage
3	10	laser reference voltage	11	element 24 voltage	12	element 24 voltage
4	13	-15v. supply voltage	14	-15v. supply voltage	15	-15v. supply voltage
5	16	electronics temp.	17	+5v. supply temp.	18	+5v. supply temp
6	19	+5v. supply voltage	20	+5v. supply voltage	21	+5v. supply voltage
7	22	+5v. supply temp.	23	electronics temp.	24	electronics temp.
8	25	+15v. supply voltage	26	+15v. supply voltage	27	+15v. supply voltage
9	28	probe temp.	29	mirror temp.	30	mirror temp.

msec = PMS elapsed second clock modulo 10

Program VHPLOT Operating Instructions (cont'd)

2.7.5.2 VHPLOT sample output & plot

Output Description

The output from VHPLOT consists of two sections (figures 2.57 and 2.58). Figure 2.57 is the input option section. The first line consists of a particular start and stop time and identification of the aircraft producing the input data. The next part describes the particular plots selected. In this example the lowest frame to be plotted (plot 1) is temperature (TEMP), and the limits of calibration are from 0 to 10,000 counts. The calibration for this plot is

$$TEMP = .32616E-7(counts^2)+.0095(counts)-49.05$$

Figure 2.58 shows a calibrated listing of each plotted value. The first two columns show the elapsed seconds. The columns of VCO values are self explanatory. An important note is that since any particular housekeeping value occurs once every ten seconds every other housekeeping value is listed. However the one selected for plotting is indicated by the word "VALUE" next to it.

The plot output (figure 2.59) shows how each of the plots is offset so that each axis limit can be easily read. Any fluctuation in any of the housekeeping curves is an indication of an instrument problem.

2.7.5.2 VHPLOT sample output & plot (cont'd)

```
START= 15-27-00        STOP= 15-35-00       E MODEL

PLOT 1 IS  VCC NUMBER  2        LABELLED TEMP
  INTERCEPT=  -50.8054   SLOPE=      .0101    MINIMUM=     0.0000    MAXIMUM=10000.0000

PLOT 2 IS  VCC NUMBER  5        LABELLED DEWPT
  INTERCEPT=  -47.6149   SLOPE=      .0097    MINIMUM=     0.0000    MAXIMUM=10000.0000

PLOT 3 IS  VCC NUMBER  7        LABELLED MAGMA
  INTERCEPT=  170.0374   SLOPE=     -.0353    MINIMUM=     0.0000    MAXIMUM=10000.0000

PLOT 4 IS HSKP NUMBER  8        LABELLED EL1VC
  INTERCEPT=    0.0000   SLOPE=     1.0000    MINIMUM=     0.0000    MAXIMUM= 3000.0000

PLOT 5 IS HSKP NUMBER 12        LABELLED EL24P
  INTERCEPT=    0.0000   SLOPE=     1.0000    MINIMUM=     0.0000    MAXIMUM= 3000.0000
```

Figure 2.57: VHPLOT - Input option section

ESEC	TIME	TEMP	DEWPT	MAGHD	EL1VC	EL24P
781	15:27:00	-17.59	-2.38	66.65	65.00	177.00
782	15:27:01	-17.65	-2.37	66.65	1427.00VALUE	1726.00
783	15:27:02	-17.69	-2.37	66.62	1260.00	3372.00VALUE
784	15:27:03	-17.69	-2.37	66.65	1553.00	1539.00
785	15:27:04	-17.68	-2.37	66.65	2780.00	2821.00
786	15:27:05	-17.68	-2.37	66.65	5144.00	5011.00
787	15:27:06	-17.72	-2.37	66.65	1957.00	2823.00
788	15:27:07	-17.75	-2.36	66.65	1506.00	1465.00
789	15:27:08	-17.78	-2.36	66.65	64.00	176.00
790	15:27:09	-17.75	-2.36	66.65	1506.00	1465.00
791	15:27:10	-17.69	-2.36	66.73	64.00	176.00
792	15:27:11	-17.66	-2.36	67.01	1492.00VALUE	1760.00
793	15:27:12	-17.71	-2.35	66.90	1359.00	3394.00VALUE
794	15:27:13	-17.77	-2.35	67.01	1554.00	1539.00
795	15:27:14	-17.73	-2.35	66.98	2779.00	2820.00
796	15:27:15	-17.69	-2.35	67.01	5144.00	5011.00
797	15:27:16	-17.66	-2.35	66.98	1956.00	2822.00
798	15:27:17	-17.64	-2.34	67.01	1505.00	1465.00
799	15:27:18	-17.58	-2.35	66.98	65.00	177.00
800	15:27:19	-17.56	-2.34	67.01	1505.00	1464.00
801	15:27:20	-17.60	-2.34	66.98	65.00	176.00
802	15:27:21	-17.63	-2.34	67.01	1440.00VALUE	1758.00
803	15:27:22	-17.61	-2.34	67.01	1255.00	3364.00VALUE
804	15:27:23	-17.62	-2.33	66.99	1554.00	1539.00
805	15:27:24	-17.60	-2.34	67.01	2780.00	2821.00
806	15:27:25	-17.58	-2.33	66.96	5143.00	5011.00
807	15:27:26	-17.54	-2.33	67.01	1957.00	2823.00
808	15:27:27	-17.56	-2.33	66.98	1506.00	1465.00
809	15:27:28	-17.59	-2.32	67.01	64.00	176.00
810	15:27:29	-17.68	-2.33	66.99	1505.00	1464.00
811	15:27:30	-17.78	-2.32	66.75	64.00	176.00
812	15:27:31	-17.35	-2.33	66.65	1494.00VALUE	1790.00
813	15:27:32	-17.38	-2.32	66.65	1360.00	3392.00VALUE
814	15:27:33	-17.37	-2.32	66.65	1554.00	1539.00
815	15:27:34	-17.33	-2.32	66.65	2779.00	2821.00
816	15:27:35	-17.78	-2.32	67.01	5143.00	5011.00
817	15:27:36	-17.69	-2.32	67.01	1956.00	2822.00
818	15:27:37	-17.68	-2.32	66.98	1506.00	1465.00
819	15:27:38	-17.78	-2.31	67.01	64.00	175.00
820	15:27:39	-17.79	-2.32	66.98	1506.00	1465.00
821	15:27:40	-17.77	-2.31	67.01	64.00	176.00
822	15:27:41	-17.72	-2.31	66.98	1471.00VALUE	1779.00
823	15:27:42	-17.66	-2.31	67.01	1313.00	3369.00VALUE
824	15:27:43	-17.66	-2.31	66.98	1553.00	1539.00
825	15:27:44	-17.66	-2.31	67.01	2779.00	2820.00
826	15:27:45	-17.63	-2.30	66.98	5144.00	5012.00
827	15:27:46	-17.59	-2.31	66.83	1957.00	2822.00
828	15:27:47	-17.57	-2.30	66.37	1505.00	1465.00
829	15:27:48	-17.54	-2.30	65.65	65.00	176.00
830	15:27:49	-17.59	-2.30	64.76	1505.00	1464.00
831	15:27:50	-1	-2.30	63.86	64.00	176.00
832	15:27:51	-1			1432.00VALUE	1821.00
833	15:27:52	-			1277.00	3368.00VALUE
834	15:27:53	-			1553.00	1539.00
835	15:27:54	-			2779.00	2020.00
836	15:27:55	-17.97	-2.29	61.39	5144.00	5012.00
837	15:27:56	-17.90	-2.30	61.39	1956.00	2822.00
838	15:27:57	-17.31	-2.29	61.43	1506.00	1465.00
839	15:27:58	-17.58	-2.29	61.35	64.00	176.00
840	15:27:59	-17.50	-2.29	61.43	1506.00	1465.00

Figure 2.58: VHPLOT - calibrated listing

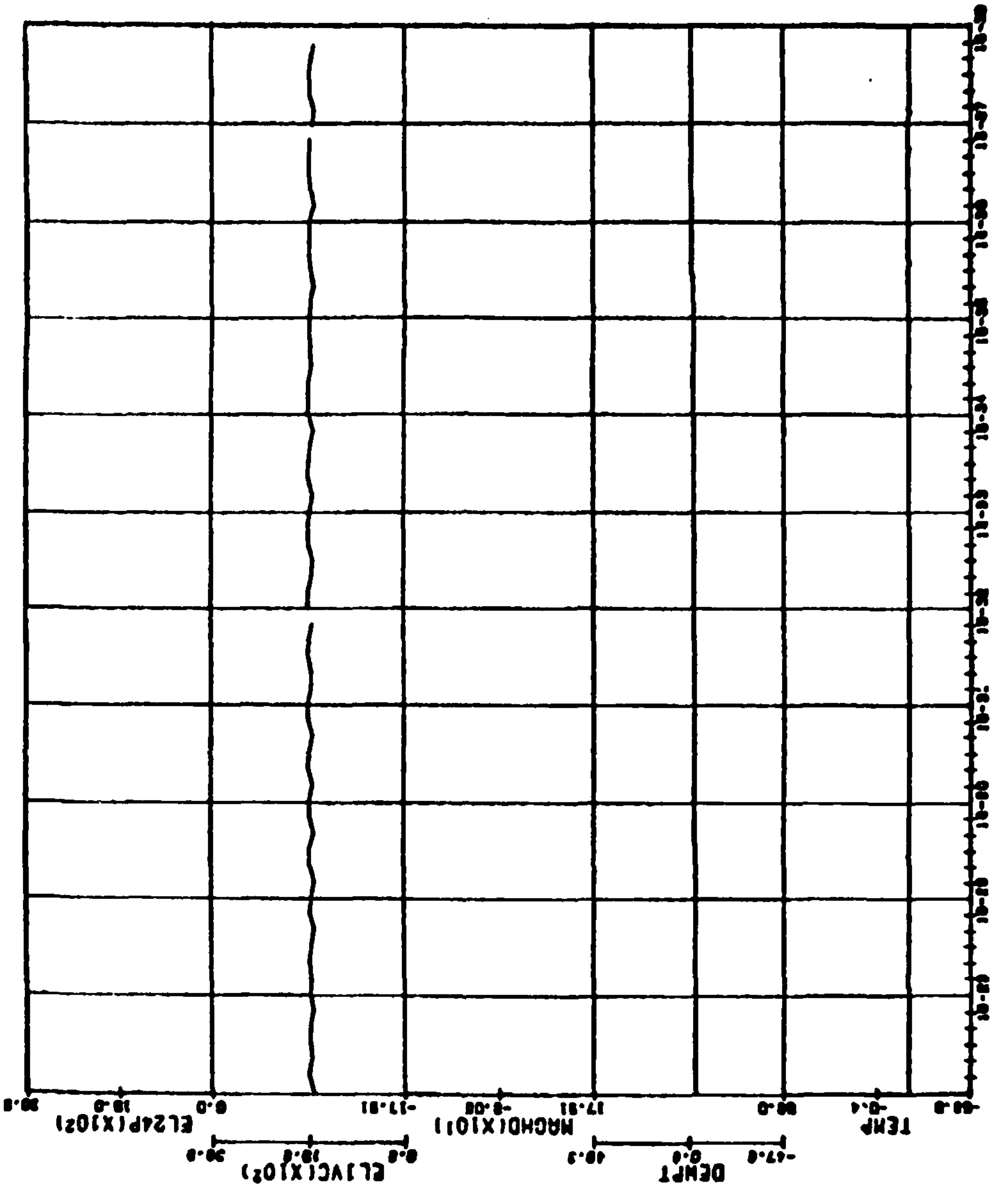
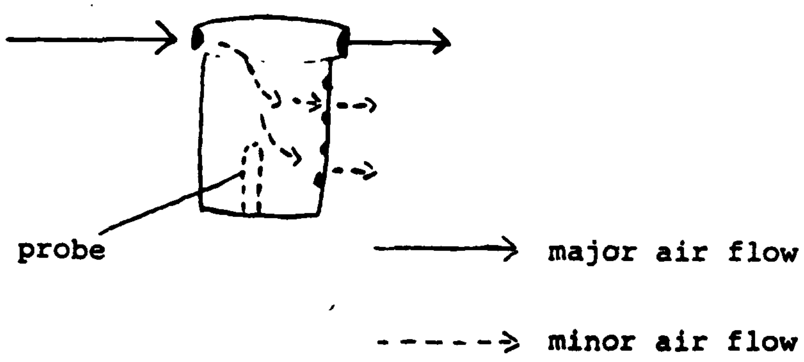


Figure 2.59. VHPLOT - sample plot

1 GO/ERASE
2 GO/SAVE
3 EXIT
ENTER OPTION

2.7.6 Program TEMPCK

AFGL Cloud Physics Branch scientists requested a program to aid them in the investigation of an algorithm to correct faulty temperature readings. The temperature probe used in the airborne data collection system is a Rosemount probe, model number 102CA24. As illustrated in the following diagram air enters the front of the probe through a small opening in the top. Most of the air, and thus the particles that entered with it, are intended to be exhausted through the main vent located at the top of the back. The air flowing outside the vertical airfoil of the probe creates a drop in pressure at the smaller outlets along the back. This produces a small but steady flow of air downward into the device past the sensing probe. However the smaller particles in the atmosphere are able to 'turn the corner' with the air, flowing into the device and past the probe, thus wetting the sensing device.



2.7.6 Program TEMPCK (cont'd)

As air passes over the wet probe the resulting cooling produces a reading lower than the air's temperature. This is easily seen in a cloud when the temperature indicated is lower than the dewpoint; a physically impossible situation. Thus the objective of program TEMPCK is to develop criteria for determining correction need and correction factor. This program uses data in the Scatter Probe range (2u-30u) only.

Program TEMPCK determines the Scatter Probe concentration value (probe number density, a value greater than 25, to indicate flight within a cloud. The correct temperature is calculated as $T(^{o}C)$ + Delta. Delta is calculated as outlines by Lenschow & Pennel as follows:

A FACTOR

Use T = Total temperature (^{o}C)

$$A = \frac{0.000586}{1 - 0.00094T}$$

D value

$$D = (L \;.\; SVP)/(RW \;.\; A \;.\; T^2 \;.\; PRESS)$$

Delta

$$D1 = D/(D + 1)$$

$$Delta = D1 \;.\; RECOVERY \;.\; TAS^2 \;/\; (2. \; CP \;.UNITCK)$$

2.7.6 Program TEMPCK (cont'd)

Result

T calculated = T + DELTA

Constants:

RW = 1.10226 E-01

CP = .240

RECOVERY = 0.972

UNITCK = 4.186E03

SVP (saturation vapor pressure)

$$SVP = A_0+A_1T+A_2T^2+A_3T^3+A_4T^4+A_5T^5+A_6T^6$$

where

A_0=6.107799961

A_1=4.436518521E-01

A_2=1.428945805E-02

A_3=2.650648471E-04

A_4=3.031240396E-06

A_5=2.034080948E-08

A_6=6.136820929E-11

Because it takes time for the probe to become wet when in a cloud, the Delta Factor is incremented from .1 Delta to 1.0 Delta in intervals of .1 every second. Thus entering a cloud:

Temp=T($^{\circ}$C) + (Delta Tenths)

where tenths = .1,.2..3.,..1.0

Conversely when exiting a cloud the Delta Factor is decremented from .9 to 0.0 for clear air.

2.7.6 Program TEMPCK (cont'd)

The reference temperature is calculated the same as true temperature in program KNOLL1D and considers the effect of aircraft velocity upon the probe. The resulting corrected temperature should be more accurate as it considers both the drop in probe pressure and probe wetting.

The relative humidity is calculated, as in KNOLL1D, by taking the percentage of the vapor pressure over the saturation vapor pressure. However the values will differ from those of KNOLL1D as program TEMPCK calculates an approximate vapor pressure using a sixth order polynomial (see report #36).

There are two vapor pressures calculated in TEMPCK. One is for the given true temperatures and the other the calculated temperature. The saturation vapor pressure is, by definition, the vapor pressure that would be present at the temperature which would bring a given parcel of air to saturation. Thus the saturation vapor pressure uses the indicated dew point as its basis.

Using the function F(X) to indicate the vapor pressure at a given temperature the calculations are as follows:

VP (Vapor pressure)	= F(temp)
CVP (calculated vapor pressure)	= F(Ctemp)
SVP (saturation vapor pressure)	= F(dew point)

RH (relative humidty) = 100 * VP/SVP

CRH (calculated relative humidty) = 100 * CVP/SVP

2.7.6 Program TEMPCK (cont'd)

The following is a brief description of the output produced by TEMPCK:

The first page of output contains information describing the probe used and the clock and airspeed options. The calibration coefficients for the 5 VCO's are also displayed.

Using the flight date as an indicator the VCO coefficients are automatically determined in the same manner as in program KNOLL1D. If the user wishes to use different values they can be obtained by use of the namelist VCOEF in the control deck.

The Scatter Probes characteristics are also a function of the flight date. To define the probe used, the user must input the type of probe (ASSP or FSSP), its location (Scatter, Cloud,or Precip cannister), and if the optional channel size is desired (2.4u instead of 2.0u).

The output is formatted to include column headers at the top of each page followed by sixty seconds of data.
Left to right, the output contains the following information:

Time
Pressure (mb)
Altitude (M)
Air speed (M/sec) either TAS or CAS
JW-LWC (g/m**3)
Concentration (N/cc)
MVD (u) mean volume diameter
Scatter LWC (g/m**3)

2.7.6 Program TEMPCK (cont'd)

True temp (^{o}C)
Corrected temp (^{o}C)
Dew point/Frost point (^{o}C)
Corrected temp-Dew point (^{o}C)
Relative humidity (mb)
Calculated humidity (Mb)
D (Delta-temp factor)
Status (clear,cloud,enter,exit)

2.7.6.1 Program TEMPCK sample output

```
     FLT E80-35          05 DEC 80

PROBE TYPE . . . . ASSP
PROBE LOCATION . . SCATTER
PROBE AREA . . . . .459 MM**2
DIODE SIZE . . . . 2.00 U


A-C CLOCK USED
PMS ON TIME  . . . 00 00 00
AIR SPEED  . . . . CAS


     VCO CALIBRATION COEFS

VCO    TYPE

 2  DEW POINT     =  -.491E+02 +   .950E-02 * COUNT +   .322E-07 * COUNT**2

 5  IND TEMP      =  -.500E+02 +   .104E-01 * COUNT +  -.440E-07 * COUNT**2

 6  JW-LWC        =  -.330E+01 +   .637E-03 * COUNT +  0.         * COUNT**2

 8  PRESSURE      =   .114E+04 +  -.101E+00 * COUNT +   .500E-07 * COUNT**2

 9  TRUE AIR      =  -.500E+02 +   .500E-01 * COUNT +  0.         * COUNT**2
```

SAMPLE OUTPUT CONTINUED ON NEXT PAGE

FLT E80-35 05 DEC 80

TIME	PRESSURE	ALT	CAS	JW	CONC	MVD	LWC	TEMP	CTEMP	DP/FP	TC-TD	RH	CRH	D	STATUS
21 23 00	650.61	3581.913	95.19	.030	47.961	10.406	.0277	-5.45	-3.54	-3.94	.40	113.7	96.7	.7678	CLOUD
21 23 01	650.81	3579.531	95.80	-.004	61.654	11.064	.0428	-5.54	-3.62	-3.93	.31	114.8	97.4	.7612	CLOUD
21 23 02	651.01	3577.149	95.90	.006	227.466	11.945	.1989	-5.48	-3.56	-3.94	.38	114.1	96.8	.7649	CLOUD
21 23 03	651.01	3577.149	96.41	.246	302.625	12.097	.2749	-5.37	-3.41	-3.94	.53	113.0	95.7	.7721	CLOUD
21 23 04	651.01	3577.149	95.98	.258	361.874	11.771	.3028	-5.29	-3.34	-3.92	.58	112.4	95.2	.7773	CLOUD
21 23 05	651.01	3577.149	95.79	.223	319.644	11.567	.2538	-5.27	-3.32	-3.90	.58	112.4	95.2	.7790	CLOUD
21 23 06	651.01	3577.149	96.34	.228	349.958	12.450	.3466	-5.32	-3.36	-3.86	.50	113.2	95.8	.7752	CLOUD
21 23 07	650.91	3578.340	95.81	.250	369.627	12.191	.3437	-5.24	-3.29	-3.84	.55	112.7	95.5	.7806	CLOUD
21 23 08	651.01	3577.149	94.68	.205	230.370	11.909	.1996	-5.16	-3.26	-3.79	.53	112.4	95.6	.7852	CLOUD
21 23 09	650.91	3578.340	94.15	.144	207.185	12.170	.1916	-5.23	-3.35	-3.76	.41	113.4	96.6	.7805	CLOUD
21 23 10	651.01	3577.149	94.21	.201	305.303	12.142	.2804	-5.27	-3.39	-3.76	.37	113.7	96.9	.7781	CLOUD
21 23 11	650.91	3578.340	94.52	.258	344.521	12.368	.3345	-5.29	-3.41	-3.76	.35	114.0	97.0	.7763	CLOUD
21 23 12	650.91	3578.340	95.17	.097	25.633	12.567	.0261	-5.43	-3.53	-3.74	.21	115.5	98.3	.7669	CLOUD
21 23 13	651.11	3575.958	96.16	-.017	.514	18.028	.0015	-5.45	-3.70	-3.75	.05	115.6	99.6	.7658	EXIT
21 23 14	651.11	3575.958	96.77	-.025	11.456	10.651	.0071	-5.36	-3.78	-3.78	-.00	114.4	100.0	.7719	EXIT
21 23 15	651.11	3575.958	96.70	-.025	2.502	13.671	.0033	-5.36	-3.98	-3.83	-.15	114.0	101.3	.7720	EXIT
21 23 16	651.01	3577.149	96.75	-.030	.026	8.057	.0000	-5.32	-4.13	-3.88	-.25	113.1	102.2	.7754	EXIT
21 23 17	651.01	3577.149	97.45	-.032	0.000	0.000	0.0000	-5.11	-4.10	-3.93	-.17	110.6	101.4	.7897	EXIT
21 23 18	650.91	3578.340	97.38	-.028	0.000	0.000	0.0000	-4.97	-4.15	-4.02	-.13	108.4	101.1	.7927	EXIT
21 23 19	650.71	3580.722	96.86	-.027	0.000	0.000	0.0000	-4.82	-4.21	-4.09	-.12	106.4	101.0	.8035	EXIT
21 23 20	650.61	3581.913	96.71	-.027	0.000	0.000	0.0000	-4.69	-4.29	-4.19	-.10	104.4	100.8	.8127	EXIT
21 23 21	650.61	3581.913	96.20	-.026	0.000	0.000	0.0000	-4.62	-4.42	-4.28	-.14	102.9	101.2	.8188	EXIT
21 23 22	650.41	3584.296	96.22	-.028	0.000	0.000	0.0000	-4.59	-4.59	-4.37	-.22	101.9	101.9	.8216	CLEAR
21 23 23	650.41	3584.296	96.34	-.028	0.000	0.000	0.0000	-4.52	-4.52	-4.48	-.04	100.4	100.4	0.0000	CLEAR
21 23 24	650.31	3585.487	96.22	-.028	0.000	0.000	0.0000	-4.44	-4.44	-4.58	.14	98.8	98.8	0.0000	CLEAR
21 23 25	650.51	3583.104	96.28	-.027	0.000	0.000	0.0000	-4.43	-4.43	-4.68	.25	97.9	97.9	0.0000	CLEAR
21 23 26	650.41	3584.296	96.14	-.027	0.000	0.000	0.0000	-4.43	-4.43	-4.80	.37	96.9	96.9	0.0000	CLEAR
21 23 27	650.61	3581.913	96.44	-.027	0.000	0.000	0.0000	-4.51	-4.51	-4.91	.40	96.7	96.7	0.0000	CLEAR
21 23 28	650.61	3581.913	96.25	-.027	0.000	0.000	0.0000	-4.57	-4.57	-5.01	.44	96.3	96.3	0.0000	CLEAR
21 23 29	650.81	3579.531	96.28	-.028	0.000	0.000	0.0000	-4.70	-4.70	-5.13	.43	96.4	96.4	0.0000	CLEAR
21 23 30	650.71	3580.722	96.36	-.030	0.000	0.000	0.0000	-4.75	-4.75	-5.23	.48	96.0	96.0	0.0000	CLEAR

2.7.6.2 Program TEMPCK operating instructions

```
DPSI,CM60000,T60,TP1.                  ID#       NAME
ATTACH,LGO,TEMPCKBIN,ID=GLASS,MR=1.
VSN,TAPE1=PMSXXX.
REQUEST,TAPE1,S,HI,NORING.
FILE (TAPE1,MRL=1024,MBL=1024,RT=U,BT=K,RB=1,BFS=105)
ATTACH,TAPE8,VCOCALS,ID=GLASS,MR=1.
MAP,OFF.
LDSET,PRESET=ZERO.
LGO.
7/8/9
```

DATA CARDS

CARD#

```
1     FLIGHT DATA
      COL                                  FORMAT
      1-10    FLIGHT ID                    FLT EXX-XX
      12-20   FLIGHT DATE                  DD MMM YY
      30-37   PMS ON TIME                  HH MM SS
2     OPTION CARD
      COL
      5       PROBE TYPE (0..ASSP,1..FSSP)
      10      LOCATION(1..SCATTER,2..CLOUD,3..PRECIP)
      15      # OF EOF'S TO SKIP
      20      0..USE TAS  1..CAS
      30      1..USE A/C CLOCK, 2..PMS CLOCK
      35      DIODE SIZE (0..2..0U,1..2.4U)
      40      PLOT TAPE INTERVAL (I5 FORMAT)
3     $VCOEF            $END            (REQUIRED)
```

2.7.6.2 Program TEMPCK operating instructions (cont'd)

4-N PASS CARDS (TIME INCREASING ORDER)

COL 1-17 HH MM SS HH MM SS

7/8/9

6/7/8/9

3. Airborne data collection

The airborne data processing work described in this report is limited to the PDP8E only. The airborne data processing on the Aeromet Learjet is not included. The requirements for the Learjet (its inputs and outputs) are however, quite similar to those used on the MC130E.

The airborne PDP8E consists of the following equipment:

1) 32K core memory and CPU
2) Twin Dectapes (non interruptable)
3) Tektronix I/O Screen/Keyboard
4) Input or output ½" magnetic tape
5) GE Terminet Printer/Keyboard
6) A to D Converter
7) Down Link output

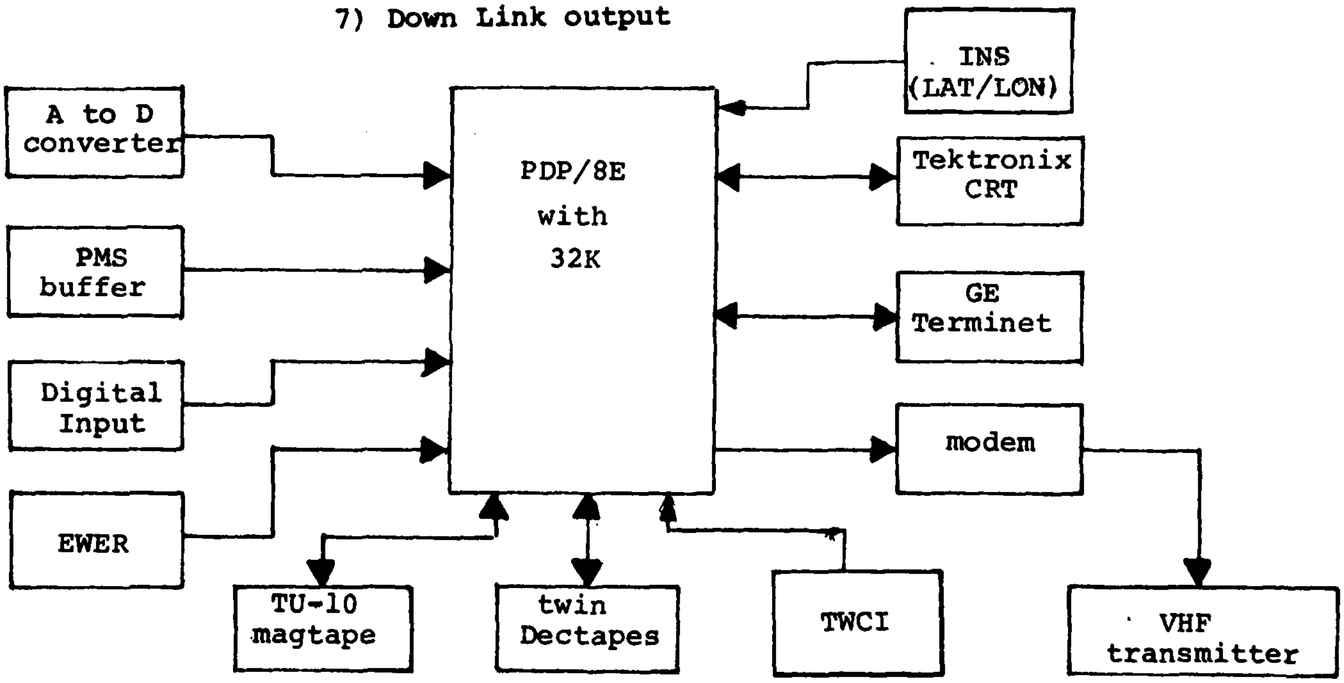


Figure 3.1: Configuration for airborne PDP/8E

3. Airborne data collection (cont'd)

There also exists a PDP8E at LYC, similar to the airborned PDP8E, and used primarily for program development. The configuration of peripheral hardware on the LYC computer is not the same as that on the airborne machine. At LYC, there is neither an A to D converter nor a GE I/O Terminet printer/keyboard. The DECwriter is used to input and the Centronicx printer for parameter hardcopy. Thus no VCO or hard-wired input comes into the computer directly. At LYC, inputs which are necessary for debugging are simulated by patch boards, or the reading of output tapes back into the computer.

In addition, there are significant differences in the IOT (input-output transfer) commands. The IOT's are the commands the programmer uses in order to obtain, make ready or output parameters from or to core locations. A complete list of these IOT's in numerical order will be found in appendix 19. The reader should note that certain IOT's are not available on the LYC computer (PMS and VCO inputs). More importantly, the programmer is cautioned that a particular IOT will execute quite differently on the two computers (see IOT 6031 as an example). Both computers use the same IOT's for the magnetic tape device. The appendix is divided as follows:

appendix 19A: All IOT's except magnetic tape handlers

appendix 19B: Magnetic tape IOT's

3.1 RTX/8 Overview

RTX/8 is an event driven, multi-programming, device independent real-time executive system. The basic program unit supported by the system is known as the "user program". User programs run under control of the executive (RTX8) and may use a powerful set of system directives which allow them to queue I/O requests and continue execution (CPU/I-O overlap at user level), manipulate event flags, trap on event declarations, communicate with other user programs via global event flags and start or stop other user programs.

3.2 Real time operating system - RTX/8

The main function of the real time system is to collect PMS, VCO, TWCI, EWER and INS data at the appropriate times, and to record these parameters on the TU-10 magnetic tape. All these data are received every second and stored in 4 second records.

The real time program, itself, is a complete operating system. It will automatically handle program interrupts for the various VCO's, the PMS inputs, the magnetic tape, the GE printer, the down-link system, the CRT, the EWER controller, the TWCI, and the INS ststem. Furthermore, it will also allow input and output to an operator who can start or stop any of the various tasks.

This monitoring is accomplished by use of a subsidiary user program ("MNSI") which is controlled by the RTX/8 real time system. To write more user programs or modify any existing user program, the details of RTX/8 should be well known.

3.2.1 RTX/8 General structure

The RTX/8 system involves three levels of programming based on the tri-state interrupt hardware of the PDP-8.

LEVEL I:

At level I there are no restrictions on program operation; all instructions are executable and operation cannot be interrupted. A level I program may opt to enter level II. Level I is automatically entered whenever an interrupt occurs at level II or level III. If an interrupt occurs at level I, there is no response to it and unless level II is entered in time, it will be lost.

All interrupt handlers operate at this level as does any non-interruptable routine such as the reading of PMS data. Level I is the most efficient level of operation since there is no overhead involved, but should be avoided whenever possible as interrupts may be overlooked.

LEVEL II:

Level II is the executive level of operation. This is known as the "Monitor". All scheduling, timing and data transfer occur at this level. In level II all instructions are executed, as in level I, but at any time processing can be interrupted by an external device, causing an immediate entry to the level I interrupt decoder. Once the interrupt is handled, the processor returns to where its breakpoint level II with all registers restored. Thus, the interrupt has no effect on the level II program other than to slow it down.

3.2.1 RTX/8 General structure (cont'd)

Whenever a level I or level II routine wishes to run another Level II program, it puts that program's entry location on the level II queue. These programs are executed in the order they were queued on a time available basis. Upon exit from any level I or II program, the level II queue is checked and the next job is run. If there are no level II tasks which need servicing, the processor enters level III.

LEVEL III:

The basis of level II is the execute queue. When there are no jobs to run in level II, the execute queue is examined. The execute queue contains a list of all currently active user programs in order of their priority. If there are no users currently active, it contains null job; a program which merely displays a pattern of lights on the front console. Thus, whenever RTX/8 has nothing to do at level I, II or III, null job is running.

Level III is interruptable as is level II; any external interrupt will cause a return to level I, but in addition, the level III user can generate an interrupt by the execution of certain instructions known as IOT instructions. These instructions are recognized by the level I interrupt handler which will with proper instructions direct the processor to various level II routines. Thus, these 'user directives' are employed by the user to communicate with the 'executive' in level II.

3.2.1 RTX/8 General structure (cont'd)

Each of these commands causes the monitor to perform a particular function. These functions deal with input/output, timing, address modification, delays, stopping and starting jobs and other functions which would cause chaos if the many users of the system were to handle them on their own. In this way, the 'Monitor' is able to supervise any function which affects more than one user and assures that users do not conflict. For instance, suppose two users wanted to use the printer. Without monitor control, the messages would mix and be garbled. The monitor will allow the highest priority user to complete a job before the other user may being. Also, the ability to halt the processor or leave the monitor system is taken away from the Level III user. There are presently nineteen user directives supported by RTX/8.

Level III is a very inefficient level of operation, due to the tremendous overhead in handling user directives and the need to restore all the major registers upon each return to this level, but it is the only level at which multiple programs can run asynchronously.

3.2.1 RTX/8 General structure (cont'd)

Each of these commands causes the monitor to perform a particular function. These functions deal with input/output, timing, address modification, delays, stopping and starting jobs and other functions which would cause chaos if the many users of the system were to handle them on their own. In this way, the 'Monitor' is able to supervise any function which affects more than one user and assure that users do not conflict. For instance, suppose two users wanted to use the printer. Without monitor control, the messages would mix and be garbled. The monitor will allow the highest priority user to complete a job before the other user may begin. Also, the ability to halt the processor or leave the monitor system is taken away from the Level III user. There are presently nineteen user directives supported by RTX/8.

Level III is a very inefficient level of operation, due to the tremendous overhead in handling user directives and the need to restore all the major registers upon each return to this level, but it is the only level at which multiple programs can run asynchronously.

3.2.2 Processor Management

The CPU is given to the user program at the head of the execute queue. Each user runs for a time slice (.25 seconds) and is then moved to the end of the queue. The system is not totally event driven due to this timeslicing approach. User programs which have just become eligible to compete for CPU time (waiting for an event which just got declared or a freshly activated program) are placed into the execute queue by priority.

Device requests are granted on a first come first serve basis. No more than five requests are allowed to stack up for any one device. If a user program attempts to use a device which is overstacked the user is moved to the event queue to wait for an event to be declared when the number of I/O requests is down to a predetermined number (currently two). This prevents a program from crashing the system by continuously making device requests, a common bug in a real time program.

3.2.3 Event Processing

RTX/8 is an event driven operating system. That is, all communication between various tasks in the system is accomplished by changing the state of the event flags. For example, when the PMS buffer fills, a particular event (buffer full) is declared and the appropriate flag is set. Any user program can respond to this event and clear the flag when the processing is complete.

Three levels of event flags are supported by RTX/8. They are:

a) system level
b) global level
c) local level

The system events are used mainly for input/output states and timing considerations and should be of no concern to the user. Global events are defined as events common to separate user programs, such as liquid water content calculation complete, and the various programs (e.g. plot LWC, print LWC and calculate LWC) can act accordingly. Local events are used within a single user program to indicate the completion of a dependent routine (e.g. completion of output string). Each user program has its own local event word.

The following event related directives are supported by RTX/8.

3.2.3 Event processing (cont'd)

CEVENT	clear event flag specified
SYNC	wait until event flag specified is declared (set)
EVENT	declare specified event (set event flag)
TEVENT	test event flag specified
ITRAP	install "trap" on specified event (a trap causes control to be passed to a specified area in the user program when the event is declared)
RTRAP	remove "trap" on specified event
TRAPE	return from a "trap"

A complete list of user directives will be found in appendix 20.

Event words are used to store the contents of all the event flags. The twelve system event flags are stored in the event word SEVT. GEVT contains the twelve global event flags. The local level event flags are stored in word 6 of each task status block (TSB see section 3.2.5.1).

Currently the defined event flags (system and global) are as follows:

System Internal Events 'SEVT': event #'s 1-12

flag or event #	meaning
1	CRT input QIO's back to allowable number
2	CRT output QIO's back to allowable number
3	DLK output QIO's back to allowable number
4	LPT output QIO's back to allowable number
5	magtape QIO's back to allowable number
6	unused
7	unused
8	DLK buffer almost empty

DLK = downlink

3.2.3 Event processing (cont'd)

flag or event #	meaning
9	LPT buffer almost empty
10	CR hit on CRT input
11	timer done for LPT output
12	timer done for CRT output

Global Level Events 'GEVT': event #'s 13-24

flag or event #	meaning
13	fresh processed KN buffer
14	new LWC ready
15	PMS-1D buffer filled (unprocessed)
16	screen erased
17	FPP done - restarts user program
18	control/C struck on keyboard
19	start 'UNIT' on VCO calibrations
20	'UNIT' done with VCO calibrations
21	LWCD done
22	time for downlink to run (every minute on 30 second mark)
23	unused
24	unused

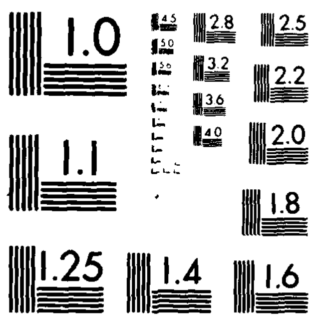
There are three basic methods employed in order to execute special routines after event completion:

a) by interrogating the global or local event word
b) by automatic execution of a trap routine
c) by waiting for completion of the event

The first technique is employed when alternative routines can be executed and a decision is made based upon completion

AD-A109 929 DIGITAL PROGRAMMING SERVICES INC WALTHAM MASS F/G 4/2
DEVELOPMENT AND APPLICATIONS OF TECHNIQUES TO PROCESS HYDROMETE--ETC(U)
JUL 81 L E BELKSY, F B KAPLAN, J P LALLY F19628-78-C-0131
UNCLASSIFIED AFGL-TR-81-0261 NL

6 of 7



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

3.2.3 Event processing (cont'd)

of the various events. The second is done when the event completion should always "trigger" a special routine to be executed (as in drawing axes after screen erase). The last is done when the programmer desires to wait until the event is complete before executing anything else.

To inquire about the status of an event (remembering that local events are numbered decimally from 25 to 36) the following code is used:

```
TAD      EVENTN        /EVENT NUMBER TO AC
TEVENT                 /EVENT INQUIRY
RETURN1                /EVENT NOT COMPLETE
RETURN2                /EVENT COMPLETED
```

The automatic execution of a routine can be accomplished using the "trap" concept within the QIO block or by the automatic execution of a routine which is event-triggered. Most automatic execution is the direct result of input/output and the trap capability is included for ease of programming. Other automatic execution will have to be utilized by the event trigger. The QIO trap will be executed every time the QIO is given, and is employed by

a) placing the first word address of eight word block in word 5 of the QIO block
b) placing the first location of the special routine in word 6 of the QIO block
c) executing the TRAPE command at the end of the special routine

3.2.3 Event processing (cont'd)

The use of the event trigger which will execute every time the event is completed requires the programmer to include the following

Somewhere in the program initialization:

```
          TAD       TRAPN     /ADDRESS OF TRAP BLOCK IN AC
          ITRAP
           .
           .
          on with the program
           .
           .
TRAPN,    .+1
          K                   /EVENT NUMBER
          .+2
          EXEC1               /SPECIAL ROUTINE START LOC.
          0                   /EIGHT WORD STORAGE
          0                   /BLOCK FOR MACHINE
          0                   /STATUS
          0
          0
          0
          0
          0
```

Somewhere in the main body of the code:

```
EXEC1,    ......              /EXECUTE SPECIAL ROUTINE
           .
           .
           .
          TRAPE
           .
           .
           .
```

3.2.3 Event processing (cont'd)

The routine starting at EXEC1 will be executed EACH and EVERY TIME the event is declared!

In order to execute the TRAPE command, the monitor must be told of the location of the eight-word machine status block. To do this:

```
TAD      TRAPN+2    /ADDR. OF 8 WORD BLOCK IN AC
TRAPE
JMP      .          /INVALID BLOCK GIVEN
```

If it is desired to continue after the trap and not return to the interrupted state then:

```
CLA
DCA  I   TRAPN+2    /ZERO STARTER WORD
TAD      TRAPN+2
TRAPE
 .                  /CONTINUE WITH CODE
 .
 .
```

When the programmer desires to stall further execution until an event is complete, he should place the event number in the accumulator and use the SYNC command, as

```
TAD      EVENTN     /EVENT NUMBER TO AC
SYNC                /AWAIT COMPLETION
 .
 .
 .
on with the program
```

3.2.4 Input/output queuing

I/O is done by queuing a request using the QIO directive. This request is made to a logical unit number which is translated by the system into a physical unit number. An event flag may be associated with the request if the user program wishes to wait for or be notified of I/O completion. CPU/IO overlap is supported since users must wait only for the request to be queued, not for I/O completion. (completion can be detected, as mentioned above, by associating an event flag with the request)

The RTX/8 system cannot allow a user to perform I/O directly because of the time consumed and interrupt returns on these IOT's. Instead the user programs a "directive" to accomplish the I/O requirement; the directive, in turn, is translated by the monitor and executed.

The directive uses a logical unit which the monitor translates into an I/O device. This translation can be altered when a peripheral device is malfunctioning so that the I/O can be handled on another peripheral device. The user's peripheral unit is referred to a logical unit number (lun) and the actual physical device is called the physical unit number (pun). Of course some I/O requests (plot, rewind tape screen erase, etc.) are inherently device-dependent and are ignored by devices that cannot execute them properly. All devices will handle the two basic functions of write (function 1) and read (function 2).

To use the Queue function, the user places an I/O block location in the accumulator and exeuctes a QIO. This packet

3.2.4 Input/output queuing (cont'd)

location is the first word address of a nine word block. The words are as follows:

word 0:	function
1:	lun
2:	tape error status word (tape only)
3:	0 (used by monitor)
4:	event number to declare upon completion
5:	eight word block location (for saving state at time of TRAP)
6:	address to trap to on completion (0 is none)
7:	I/O buffer address
10:	negative word count

The following tables are assumed

FUNCTIONS	
1	write
2	read
3	plot
4	screen erase
5	hard copy
6	rewind

LUN'S	
0	system only
1	CRT input
2	CRT output
3	DLK output
4	LPT output
5	Magtape

ERRORS	
1	invalid lun
2	illegal event
3	device locked
4	device inoperative

Immediately after a QIO is executed, the accumulator should be queried. If it is zero the I/O has been queued but not necessarily executed. If it is non-zero, the accumulator contains the ERROR number (see table). In order to verify the actual execution of the I/O request, the user will have to use the SYNC command (see appendix 20) then check word 2 of the block. At the present time only tape commands can have an error (i.e. line printer and CRT devices will NOT have an error code in word 2 at completion). In the event of a tape error the tape status word is placed in this word 2.

3.2.4 Input/output queuing (cont'd)

Word 4 contains the EVENT number (see the discussion on EVENT); an event number is required if words 5 and 6 are specified; words 5 and 6 are used for an automatic trap on event completion, where word 5 is the first word address of an eight word block for storage of machine state and word 6 is the location in the user's program where a special routine (trap service routine) is to be executed after the QIO completion.

Words 7 and 10_8 are used for the information to be input/output; word 7 is the first word address of the locations being read or written, and word 10 is the negative length.

TEKTRONIX OUTPUT

The various 8-word QIO blocks for Tektronix output are:

Alphabetic Output	Line Plot	Plot alpha in graph area	Screen erase	Hard Copy Screen erase
1	3	3	4	5
1	1	1	1	1
0	0	0	0	0
0	0	0	0	0
E	E	E	20_8	20_8
Z	Z	Z	Z	Z
Z1	Z1	Z1	Z1	Z1
CH1	CH2	CH3	not used	not used
-L1	-4	-L3	not used	not used

3.2.4 Input/output queuing (cont'd)

CH1	CH2	CH3
"A	OLDY	PRNTY
"B	OLDX	PRNTX
"C	NEWY	7777
215	NEWX	"A
212		"B
(L1=5)		"C
		(L3=6)

When plotting a line segment:

OLDY = y-coordinate of first point of line segment
OLDX = x-coordinate of first point of line segment
NEWY = y-coordinate of second point of line segment
NEWX = x-coordinate of second point of line segment

A line will be drawn from (OLDX,OLDY) to (NEWX,NEWY) each coordinate bounded by 0 to 640

When printing alphanumeric in plot area:

PRNTY = y-printing coordinate of first character; y must be 1 through 35 (indicating line number)
PRNTX = x-printing coordinate of first character; x is bounded by 0 and 39 (indicating characters to be skipped from beginning of line)
E = event number; if no event is to be flagged, set E to 0. event number must be 16_{10} if screen erase or hard copy is used; E must be specified if Z is specified

3.2.4 Input/output queuing (cont'd)

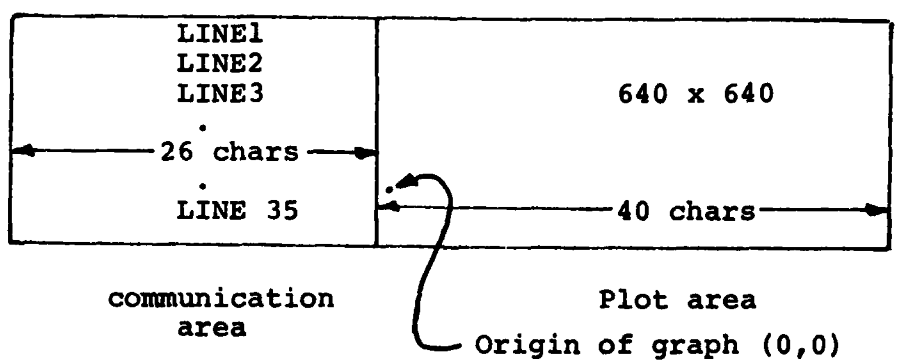
Z = trap location; if no trap is used, set Z to 0. If Z $\neq$ 0, it must be the first location to be executed after the output is performed; the user will handle the trap interrupt and end the routine with the proper TRAPE instruction in order to resume normal execution

Z1 = block storage address; to be used only whe Z $\neq$ 0. Z1 is the first of 8 locations the monitor uses in storing the machine state. Z1 is also used in TRAPE.

Raster Flash location, X,Y.

The system retains the coordinates of the next printing character in locations X and Y on page 0, field 0. X is started at 0 and stepped by 16_{10} for each character. Y is started at 767_{10} and decreased by 22_{10} for each line advance.

Tektronix Screen layout



3.2.4 Input/output queuing (cont'd)

There are 35 lines for printing; those lines which are printed in plot area appear half way between lines printed in communication area; that is, Y takes on values 767,745,723,...,41,19 while plot lines have values 756,734,712,...,30,8.

The user need not concern himself with Y and X as they are automatically advanced. With printing in the plot area, the user specifies

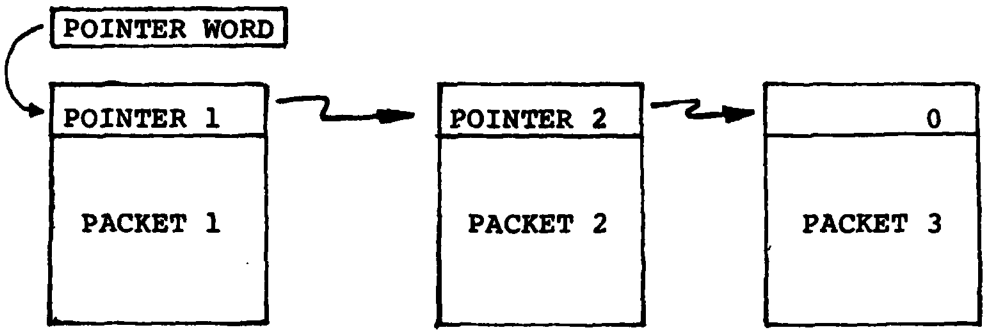
$$1 \leq \text{PRINTY} \leq 35$$
$$0 \leq \text{PRINTX} \leq 39$$

The monitor will calculate the correct rasters for x,y.

For graph identification, 5 lines will print below the graph: lines 31,32,33,34,35. Also line 30 will be cut by the x-axis, if drawn. To label the top of the ordinate use x = 1, y = 1 as the coordinates of the first character.

3.2.5 Data base structure

All packets are queued in linked lists with the first word of one packet pointing to the first word of the next. In this way, packet order can be rearranged without moving large blocks of information. Dynamic storage is also linked together and a packet of any size can be parcelled from or returned to the linked list. All linked lists including dynamic memory are restricted to data field 3 (DATFLD).



The last packet in any linked list contains a zero.

3.2.5.1 Task status block 'TSB' or 'USB'

In DATFLD; fixed in core
one for each task in system
30_8 word block

Word	Function
0	linkage word for queuing
1	priority (1-256)
2	task status: (bit 9-waiting for event, 10-serving trap, 11-active)
3	event no. if waiting for event
4	head of task trap list
5	head of trap queue
6	task local event word
7	task initial starting address
10	machine status word (field & mode)
11	PC
12	Link & EAE mode
13	contents of user location 10
14	contents of user location 11
15	MQ
16	AC
17	SC
20	Logical Unit Table | 0 | 1 | logical unit vectors into
21	Logical Unit Table | 2 | 3 | table containing physical
22	Logical Unit Table | 4 | 5 | unit
23	Reserved for future development
24	Reserved for future development
25	taskname } 4 char in sixbit
26	taskname
27	FPPAPT address (free core F3)

3.2.5.2 Device status block 'DSB'

In DATFLD, fixed in core
one for each device on system
(note: terminals are considered to be 2 devices)
10_8 word block

Word	Function
0	Link to I/O packet queue
1	Status word bit: 11 active; 10 locked; 9 shut down; 8 QIO's overstacked
2	function
3	I/O buffer addr
4	WC
5	physical unit no. (PUN)
6	owner of locked device (TSB addr)
7	entry point for driver initialization

3.2.5.3 I/O packet

In DATFLD, executive dynamic storage
one for each outstanding I/O request, in linked list by device
released to free core list upon I/O completion
13_8 word block

Word	Function
0	-13 (block length for exec storage routines)
1	link to next I/O packet (0 if end of queue)
2	function
3	logical unit number (lun)
4	addr of error word in task area
5	TSB addr
6	event to set on completion (0 if none specified)
7	addr to save machine state at time of trap
10	trap addr (0 if no trap requested)
11	I/O buffer addr
12	-WC

I/O buffer addr is the address of an I/O buffer in the task area

DSB	I/O pack	I/O pack	I/O pack

up to 5 packets may be queued for each device

3.2.5.4 Trap blocks

In DATFLD, exec dynamic storage
one for each trap requested, in linked list by task
can be "once only" trap meaning when trap is executed the
trap block is returned to free core

2 types:

<u>Executive Level Traps</u>

once only traps
in linked list headed by "XLT" (exec trap list)

word	Function
0	-4 (WC)
1	link to next entry
2	event to trap on
3	trap addr (a level 2 entry point into executive)

XLT	trap block	trap block	trap block

<u>Task Level Traps</u>

can be permanent or once only
in linked list by task, list headed by TSB word 4

word	Function
0	-5 (WC)
1	link to next entry
2	event no. to trap on; bit 0 set for once only traps
3	addr to save machine state at time of trap
4	PC for trap service

3.2.5.4 Trap blocks (cont'd)

TSB	trap block	trap block	trap block

if a trap occurs while task is servicing a trap, the trap which just occurred is queued into a linked list of outstanding traps by copying the trap block and linking it to a list headed by TSB words.

3.2.5.5 Clock blocks

In DATFLD, exec dynamic storage
used to mark off a specified time interval and declare an event at the end of the interval
one for each MARKT directive or system level mark time
returned to free list at end of time interval
in linked list headed by 'CLOCKQ'

word	Function
0	-5
1	link to next entry (0 means end of list)
2	event to declare on completion
3	-# ticks left
4	TSB of task which issued MARKT (relevant only for task local events)

CLOCKQ	clock block	clock block	clock block

3.2.5.6 Floating point processor

One of the most significant changes to tne structure of the original RTX/8 operating system was the installation of the floating point processor (FPP). The FPP is capable of performing mathimatical calculations at speeds much greater than the previously used software floating point package. In addition to the speed increases, the FPP requires no software decoder as did the F.P. package.

The FPP device handler installed in the final version of the RTX/8 system is a product of extensive testing and debugging. The handler has been designed to allow multiple users. If a job is using the FPP and a second user requests its use too, the second job is put into a queue and 'held' until the first job terminates device use. The second job is then run.

During development of the FPP handler, a few problems were encountered. Perhaps the most perplexing was related to the processing of PMS 1D data while the FPP was inoperation.

RTX/8 operates the FPP in 'interleaved' mode; which allows both the PDP-8/E and the FPP to run simultaneously by sharing data breaks. The problem with this mode however is that the PDP-8 is running at half speed. When the PMS signals data ready, RTX/8 enters level 1 to process the data; if FPP is running, the PDP-8 cannot finish PMS processing before the next KNOLLENBERG interrupt. To alleviate this, the PMS handler halts the FPP to achieve full speed operation. When the

3.2.5.6 Floating point processor (cont'd)

PMS routine is done, the FPP is restarted where it left off.

The flow chart of the entire FPP device handler is displayed in figures 3.2 - 3.4. The format of the Active Parameter Table is given in table 3.1.

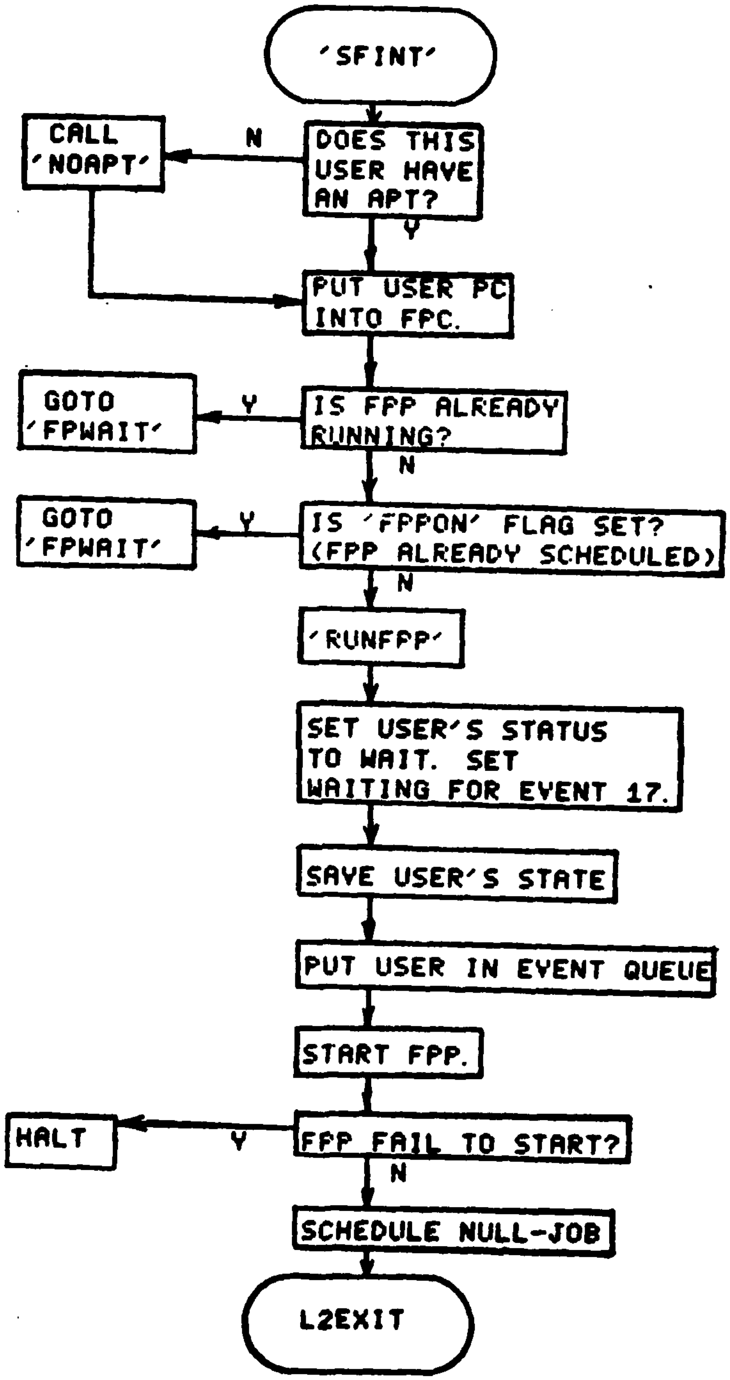


Figure 3.2: FPP device handler
FPP initialization routine

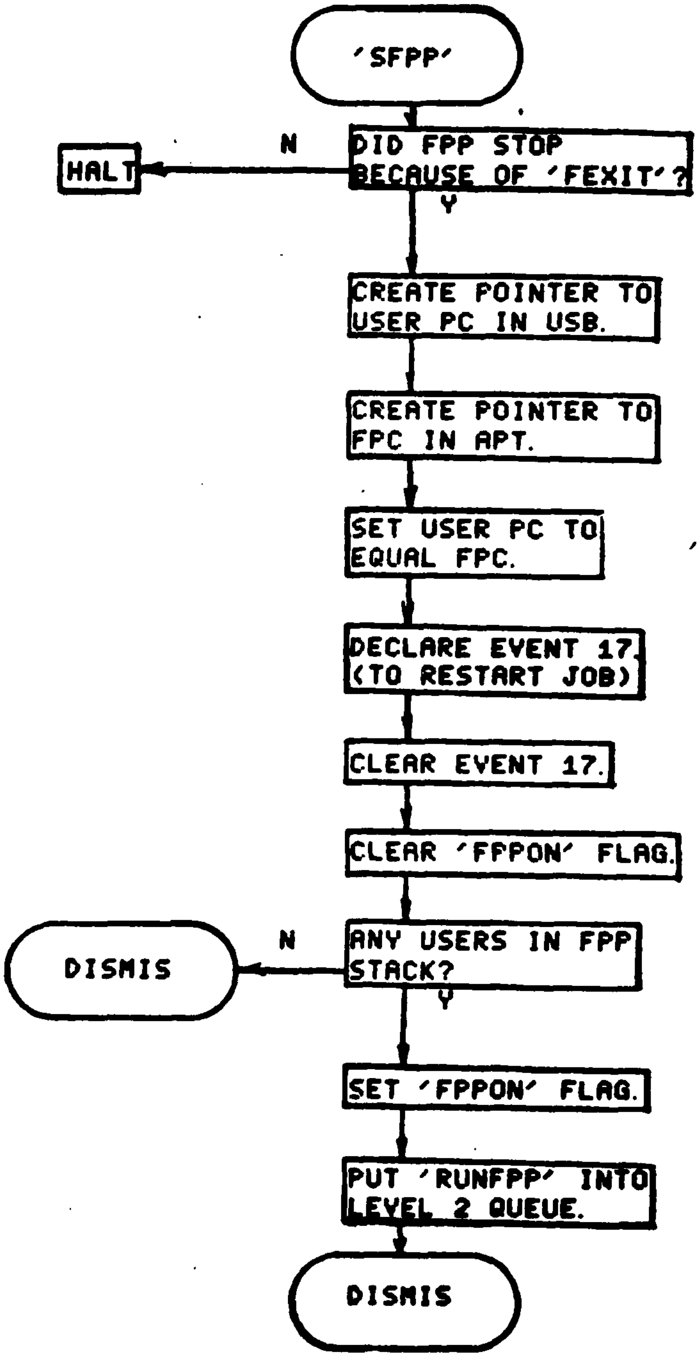
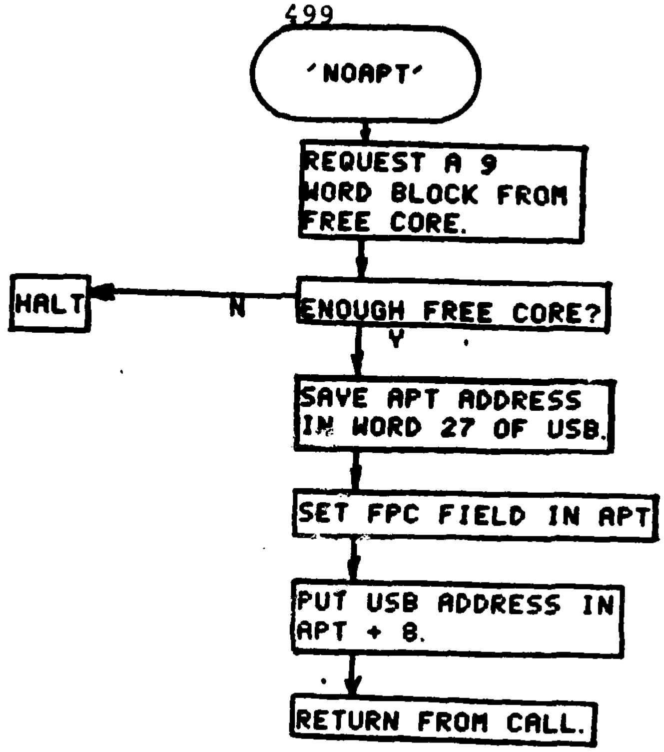
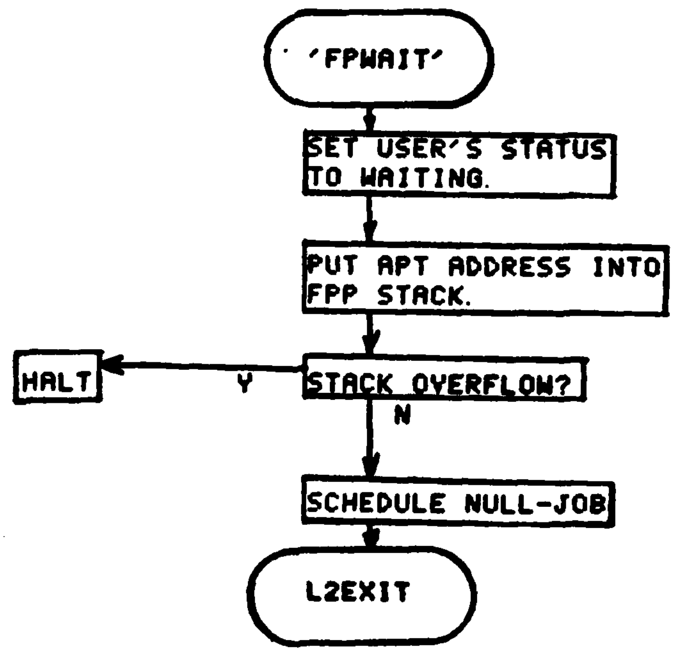


Figure 3.3: FPP device handler
FPP interrupt completion routine



Create APT from free core



Put user into FPP stack

Figure 3.4: FPP device handler

3.2.5.6 Floating point processor (FPP) (cont'd)

In DATFLD (free core). One for each user requiring FPP use.

Word	Function
0	field bits (ABCD)
	A = operand address field
	B = base register field
	C = index register address field
	D = FPC field
1	Floating program counter (FPC)
2	Index register address
3	Base register
4	Operand address
5	Floating accumulator exponent
6	FAC Hi order bits
7	FAC Lo order bits
10	User status block address

Table 3.1: Active Parameter table

3.2.6 PDP/8E interrupt monitor

The PDP-8 interrupt monitor is a modified M1703 card installed in the PDP-8 computer at AFGL. By attaching an oscilloscope to the appropriate leads on this board the interrupt timing of the real time system can be modified.

Lines:

USER(Blue): This line is taken off the Omnibus and is low when the PDP-8 is in user mode

ION(Green): This line indicates whether the interrupt system is on or off. (low is on)

When these lines are looked at with a two channel scope in ADD mode, they produce a three level picture of the interrupt timing corresponding to the three levels of real-time operation. This is an invaluable tool in troubleshooting hardware as well as software problems.

3.2.7 Data retrieval

It can be seen from the following output allocations of the TU-10 tape buffer that the retrieval of a specific value can be quite difficult. The following functions are given to isolate the desired quantities:

(a) From the fast VCO data (appendix 1)

1. let t = time desired
2. let t_o = time at beginning of block
3. let k = one of the 14 desired words

$$\text{location} = 14\,(t-t_o) + k$$

(b) From the Knollenberg PMS and VCO blocks (appendix 18 & 8)

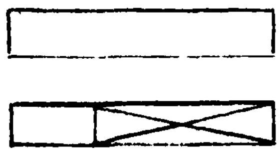
1. let t = time desired
2. let t_o = time at beginning of block
3. let i = item desired (1-64, as in appendix 8)

$$X = 112 + \left[(t-t_o)256 + 4\,i\right]/3$$

L = integer part of X

R = fractional part of X

if $R = .333$ the information is in L + the next 4 bits

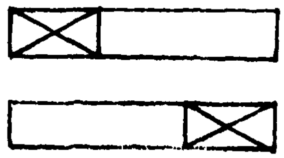


L

L + 1

if $R = .667$ the information is in the right 8 bits of L, and the left 8 bits of $L + 1$

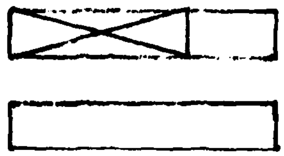
3.2.7 Data retrieval (cont'd)



L

L + 1

if R = 0, the information is in the right 4 bits of L - 1 and in L



L - 1

L

(c) From the status words (appendix 18)

1. let j = item desired (1-30)

   X = (j-1)/3

   L = integer part of X

   R = fractional part of X

   set $t = t_o + 3R$, and set

   i = 48R + 17

   and follow the procedure of (b)

3.2.8 Building the operating system

The RTX8 system is compiled in four sections:

RTX8 — The real time executive and Dynamic storage covers memory fields 0 and 3. Conditional assembly: AIRPL = 0 for Hanscom version (RTX8H) and AIRPL = 1 for Airplane version (RTX8). All development is done on RTX8H and then recompiled as RTX8.[1]

SYSLIB — RTX8 systems library. Includes: systems interpreter, magtape program, print program and PLOT program. Unconditional assembly. Occupies field 1.

LWC — Includes liquid water content calculation program and program 'UNIT' to calculate the VCO's for printing. Field 2. Unconditional assembly.

LWCFTC — FPP functions used by LWC. (Field 2). Includes FPP I/O output conversions, SQRT and LOG functions.

To load the system, all binaries should be on Dectape 1 including RTX8.BN, SYSLIB.BN, LWC.BN and LWCFTC.BN.

```
R ABSLDR ↓
*A:RTX8,SYSLIB ↓
*A:LWC,LWCFTC (ALT MODE)
.SA SYS RTX8 0-7577,10000-17577,20000-27577,30000-33000;5=0 ↓
.R RTX8 ↓
```

To get back to OS8 from RTX8, type CTRL/K

3.2.8 Building the operating system (cont'd)

NOTES:

[1]RTX8 must be assembled with the K option using PAL 8

3.2.9 Operating instructions

1. Mount system tape on dectape 0
2. Turn Tektronix screen and hard copy unit on
3. Put 7470 in switch register
4. Press: a) LOAD ADDRESS
   b) EXT ADDRESS
   c) CLEAR
   d) CONTINUE

   There should now be a '.' on the screen
5. TYPE: R RTX8 (there must be a space between the R and and RTX8)

   There should now be an '*' on the screen.

   The '*' means RTX8 is waiting for a command
6. When RTX is started it will ask for the date. TYPE in the date in the form DD-MMM-YY. Also add the flight number.
7. PUT console knob on AC this will display a rotation of lights on the computer

<u>Commands recognized by RTX8</u>

CTRL C	causes an * to be printed on the screen and gets the attention of RTX8 as programs can be turned ON or OFF
CTRL E	erases the screen and positions printing cursor back at the top left hand of the screen. No hard copy will be printed
CTRL P	prints what is on the screen on the hard copy unit and erases the screen
CTRL K	return control to OS/8 keyboard monitor
CTRL U	deletes current input command string

3.3 Real time aircraft processing: user programs

The RTX8 is actually an operating system rather than an executing program. It has, built into it, the capability to take all inputs from VCO's and PMS, to record them onto magnetic tape, to display parameters on the printer, to plot parameters, etc., all within the constraints of real time. It has a further capability to execute subsidiary, or user programs. To execute any user program the operator enters the "ON" command followed by the appropriate user program name.

The following list summarizes the current user programs available within RTX/8. Note that the two starred user programs are not directly executable by keyboard initiation. MNSI can be called only by the monitor. UNIT is only called (as needed) by the USER program PRINT. Details and operating instructions of the remaining user programs are detailed in the following sections.

New user programs may be added by updating the user count (on page 0) and installing a user status block (USB) describing the job into the USB list in DATFLD.

<u>Present users</u>

MNSI*	The systems interpreter. This user activates the keyboard and starts and stops other users according to commands from the keyboard
TAPE	writes the contents of the RTX/8 buffer onto magtape
PRINT	prints selected parameters on the line printer

3.3 Real time aircraft processing: user programs (cont'd)

UNIT*	A sub-user initiated by PRINT which calibrates the raw VCO data and sends it to the print buffer
LWCD	Computes liquid water content from the raw probe counts
PLOT	Plots the LWCD values on the Tektronix screen
DPMS	Allows real time Knollenberg printer dumps
CHECK	Reports end elements values below a certain level
TWCI	Displays TWCI data on the printer

* special user programs (not directly executable via keyboard)

3.3.1 User program TAPE

Program TAPE assumes the VCO input in the form shown in appendix 1, and it assumes the PMS data coming in at a rate of 256 characters (4 bits) per second. The output on magnetic tape is in the form shown in appendix 18.

<u>Operating instructions</u>

1. Put a tape on the TU-10 (make sure tape drive is on-line)

2. TYPE: ON,TAPE↓

   To terminate this program

   TYPE: OFF,TAPE↓

Possible errors could be:

TAPE - ERROR	magtape hardware error or no write ring
RTX/8 - magtape hung/off line	the magtape unit does not respond to RTX/8 check 'ONLINE/OFFLINE' switch

3.3.2 User program LWCD

The total liquid water content is calculated using the following equation:

$$LWC = \frac{\pi}{6} \rho \sum_{p=1}^{2} \sum_{i=1}^{15} N_{i,p} D_{i,j,p} \qquad \text{in grams/M}^3$$

where $\rho = 10^{-3}$ mg/cm^3

p = probe (Cloud = 1, Precip = 2)

i = channel (1-15)

j = particle type (1-5) input parameter

$D_{i,j,p}$ is the channel diameter cubed. To minimize execution time the program has these values stored in a 150 element three dimensional table. (5 types x 2 probes x 15 channels)

$N_{i,p}$ is the particle number density for a given channel; the program calculates this value as shown

$$N_{i,p} = \frac{count_{i,p}}{vol_{i,p}}$$

where $count_{i,p}$ = observed PMS particle counts

$vol_{i,p}$ = sampling volume

The program obtains the observed PMS particle counts directly from the PMS 1D double buffer.

3.3.2 User program LWCD (cont'd)

The sampling volume calculation is shown in section 2.1.1.5. To save time and eliminate repetitive calculations the program determines this volume in two steps. (Note that in section 2.1.1.5 the sampling volume is defined as the product of the cross sectional area times the distance travelled during the sample period.) The cross sectional areas have all been stored as a two dimensional table within the program. This table contains 30 entries (2 probes x 15 channels). The distance travelled is calculated in the program as the product of velocity (an input parameter) converted to meters/second times the sample period (an input parameter).

The particle types used in LWCD are

1 Rain
2 Wet snow
3 Large snow
4 Small snow
5 Bullet-Rosettes

LWCD, additionally, performs several auxillary calculations. These include: radar reflectivity (Z), form factor (F), MK and number totals (NT). 'LWC', 'Z', 'F', and 'MK' are sent, in ASCII, to the output buffer used by program PRINT and in fixed point, single precision (with a scaling factor) to the PLOT program. These values are calculated in the following manner.

3.3.2 User program LWCD (cont'd)

Z

$$Z = \sum_{p=1}^{2} \sum_{i=1}^{15} N_{i,p} \, (D_{i,j,p})^2 \qquad \text{in } mm^6/M^3$$

note N and D have been previously defined

MK:

The ratio of liquid water content to the square root of radar reflectivity can be expressed as:

$$MK = \frac{1000*LWC}{(Z)^{1/2}} \qquad \text{with LWC in grams}/M^3 \text{ and Z in } mm^6/M^3$$

Form Factor:

Form factor requires an intermediate calculation, NT. This is defined as:

$$NT = \sum_{i=2}^{15} N_{i,1} \, D_{i,j,1} + \sum_{i=1}^{15} N_{i,2} D_{i,j,2}$$

This is essentially the same as the LWC computation except channels 1-4 of the Cloud Probe are omitted. Once NT has been derived, form factor is calculated as:

$$F = \frac{MK}{\frac{\pi}{6}(NT)^{1/2}}$$

3.3.2 User program LWCD (cont'd)

<u>Stability factor</u> :

Given the form factor, and concentration (NT) the stability factor is calculated as:

$$S = (NT)^{\frac{1}{2}}/F$$

<u>Operating instructions</u>

TYPE: ON,LWCD↓

<u>VELOCITY:</u>
<u>HARDWARE INPUT OKAY?</u>

If the true airspeed is to be used, type "Y". If keyboard input is desired, type "N". If "N", the system responds with

<u>VELOCITY:</u>

Type the velocity in knots

<u>PARTICLE:</u>
<u>HARDWARE INPUT OKAY?</u>

If "N", RTX-8 types:

<u>PARTICLE TYPE (1-5)?</u>

Select the proper particle type:

3.3.2 User program LWCD (cont'd)

1 = RAIN 2=WET SNOW 3=LARGE SNOW 4=SMALL SNOW 5=BULLET-ROSETTES

PROBE:C,P, or B?

Select Cloud Probe, Precipitation Probe, or B for both.

3.3.3 User program PRINT

This user program sends one line of information to the GE Terminet printer each time the Knollenberg buffer fills (every four seconds). This contains calibrated VCO readings, a time code, LWCD results and a particle distribution. A brief description of each of the output parameters follows:

PT	Particle type (R=rain, W=wet snow, L=large snow, S=small snow, B=bullet rosettes)	
ET	Elapsed time as read from PMS-1D buffer	
TIME	From Stancil Hoffman time code generator. Hours, minutes and seconds (HH:MM:SS) are included on line 1, seconds only appear on lines 2-15	
ALT	Altitude in kilofeet: calculated as a fifth degree polynomial from the Kistler pressure reading	
TEMP	Temperature in degrees centigrade	
MAGH	Magnetic heading in degrees (0-360°N)	
Dewpoint	in degrees Centigrade	
TAS	True airspeed as read from the TAS computer	
JW-LWC	reading from the Johnson-Williams device	
EWER	LWC reading as output from the NOVA computer	
LWC	liquid water content results	
Z	radar reflectivity	from user program LWCD
MK	$M/\sqrt{Z}$ ratio	
F	form factor computation	
ICED	raw ice detector value	
NT	number totals	

The particle distribution is displayed as one minute sums for the 15 PMS size channels. Note that the 45 sums that appear are sums of a one minute interval <u>ending</u> at the

3.3.3 User program PRINT (cont'd)

time associated with the data. This is in the output format shown in figure 3.5, the first set of sums are for particles during 12:03:00 to 12:04:00.

Operating instructions

1. Turn Terminet printer <u>ON</u>
   The switch is on the back and at the right as you face it.

2. Press the LOCAL button hit a carriage return and make sure there is a 1 in the print column light.

3. Position paper so it will begin printing at the very top of the page.

4. Press the ON LINE button, the READY light should be on if everything is all set.

5. To activate the PRINT program type
   ON,PRINT

NOTE: The PRINT program will only print LWC, Z, MK, F, NT if the LWCD program is on. Otherwise only the VCO and probe counts data will be printed.

CH	SCAT	CLOUD	PREC	PT	SEC	ET	VCO_1	...	VCO_9	LWC	Z	MK	F	ICED	NT
1	SSSS	CCCC	PPPP	TT	HH:MM:SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	X.XX
2	SSSS	CCCC	PPPP	TT	SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	X.XX
3	SSSS	CCCC	PPPP	TT	SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	X.XX
4	SSSS	CCCC	PPPP	TT	SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	X.XX
.															
.															
.															
13	SSSS	CCCC	PPPP	TT	SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	X.XX
14	SSSS	CCCC	PPPP	TT	SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	
15	SSSS	CCCC	PPPP	TT	SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	
1	SSSS	CCCC	PPPP	TT	HH:MM:SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	
2	SSSS	CCCC	PPPP	TT	SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	X.XX
3	SSSS	CCCC	PPPP	TT	SS	SEC	V_1		V_9	XX.XX	.XXXE$\pm$XX	X.XX	XX.X	XXXX	X.XX
.															
.															
.															

SSSS = Scatter probe counts
CCCC = Cloud probe counts
PPPP = Precip probe counts
HH = 2 digit hours

MM = 2 digit minutes
SS = 2 digit seconds
SEC = PMS elapsed second
$V_1 \ldots V_9$ = VCO calibrated values

Figure 3.5 : Printer Output Format

3.3.4 User program PLOT

This user program plots the data output by the LWCD program on the Tektronix CRT. This includes LWC, F, S, MK and I. The operator can choose any one of these parameters to be plotted; if M is chosen, a choice of three ranges is avialable. The axes are drawn on the right half of the CRT, leaving the left side for operator dialog. Each plot is labelled with function, time, maximum value and date so it can easily be identified. Each tick mark on the ordinate represents one minute. On the abcissa a tic represents one-fifth of the maximum. After five minutes, the plot fills up and automatically a hard copy is made, the screen erased and new axes are drawn and labelled. A new plot is also generated whenever the screen is erased by operator dialog filling the screen, or a control/E or control/P function.

If any data exceeds the plot maximum, an interpolation is done and a line drawn to where the line would have left the plot area. This also occurs when the data returns to the range of the plot.

3.3.4 User program PLOT (cont'd)

Operating Instructions
NOTE: This program plots data generated by program LWCD. PLOT will not run unless LWCD is first activated.

ON,PLOT↓

PLOT:K,F,M,S, OR I?

Respond with the desired plot parameter followed by a carriage return (↓). If the operator reply was anything but M; an asterisk will be printed in the left margin, the axes will be generated and plotting will commence. If the operator reply was M the system responds with

RANGE:
1: 0-10
2: 0-1.0
3: 0-0.1
SELECT RANGE:

Respond with either 1,2, or 3 followed by a carriage return, selecting the range best suited for the current weather conditions.

At any time the plot or range may be changed by typing:

OFF,PLOT ↓
↑P (Control/P to erase screen & make copy)
ON,PLOT ↓

continue with desired parameters

3.3.5 User program DPMS

RTX/8 user program DPMS is included with the operating system to enable real time printer dumps of Knollenberg data.

When DPMS is started (by typing 'ON DPMS'), it aborts users PRINT and LWCD (displays a message if users did in fact abort) so they cannot compete for printer and FPP use.

DPMS is restricted to dumping only one fourth of the Knollenberg buffer available. This is due to the amount of data and the speed of the printer. DPMS determines the print parameter by sensing the PDP8 front panel switch.

Bit 10	Bit 11	Parameter
0	0	VCO
0	1	Scatter
1	0	Cloud
1	1	Precip

1 = SWITCH UP
0 = SWITCH DOWN

Printer output is paged with a heading indicating the data parameter followed by 60 lines of data. At any time the parameter may be changed by changing bits 10 and 11. At that time, a form feed and new heading will occur.

DPMS is terminated as any other user program: 'OFF DPMS'. LWCD and PRINT must be re-initialized if desired.

3.3.6 User program CHECK

User program CHECK is started by typing 'ON CHECK'. Its function is to monitor end element values. If an end element drops below 3.0 volts, a message is displayed on the Tektronix screen.

The end element error message appears in the form:

PP: EEEE = XXXX

Where:

PP	CL for CLOUD PR for PRECIP
EEEE	EL01 for end element #1 EL24 for end element #24
XXXX	the value in error

DPMS is terminated by:

OFF DPMS

3.3.7 User program TWCI

User program TWCI will reproduce the TWCI report on the GE Terminet printer. When started, TWCI will turn PRINT off so output is not garbled. No other operator intervention is necessary.

Every 4 seconds TWCI will copy the TWCI report to the printer. The top of each page is a heading, followed by 60 lines of data. Program termination is accomplished via the OFF command. The PRINT program must be restarted.

3.3.8 Special User program MNSI

MNSI is the keyboard monitor and allows interfacing the operator to RTX/8. MNSI carries out the ON and OFF commands and also requests the date/flight at system start up.

MNSI is not directly controllable by the operator in regard to its running. When RTX/8 is started, MNSI is put into the execute queue and runs automatically. To turn off MNSI would result in a locked system, that is, RTX/8 would not respond to the operator. RTX/8 would have to be restarted.

3.3.9 Special user program UNIT

UNIT is very much like MNSI in that it is not controlled directly by the operator. UNIT is used by the PRINT program to calibrate the VCO's.

When the Knollenberg buffer is full, PRINT sums the probe counts and then declares event 19 to start UNIT. When the calibrations are complete, UNIT declares event 20 and PRINT sends the data line to the printer.

4. In-house computers

4.1 The LYC PDP8E computer

The PDP8 computer at LYC consists of the following equipment

1) 32K (MOS memory and CPU)
2) Twin Dectapes (non interruptable)
3) Tektronix I/O Screen/Keyboard
4) Input or output ½" magnetic tape
5) Dec-writer
6) Bootstrap loader in read-only memory (ROM)
7) Centronics printer
8) High speed paper tape reader

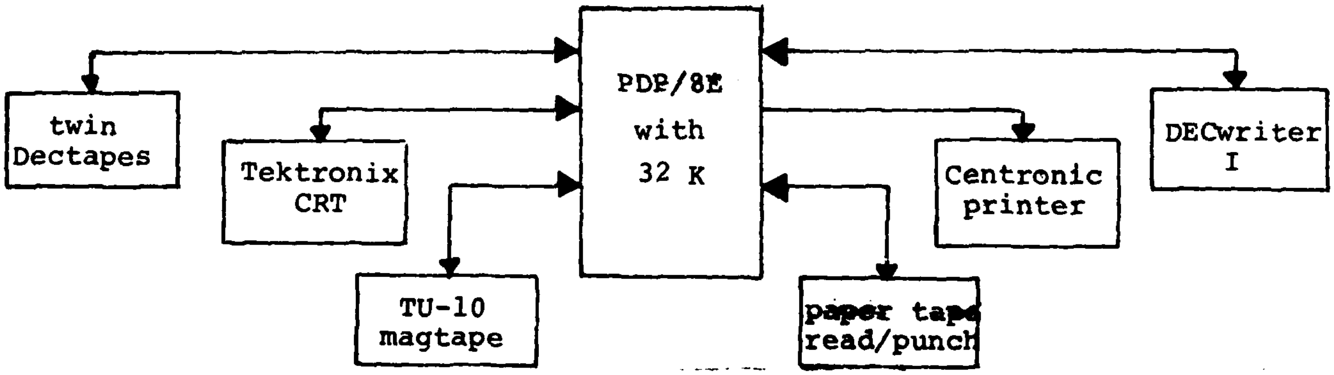


Figure 4.1: PDP8E block diagram

The magnetic tape is usually utilized as an output device (PAL8, CREF) but can be used as input, especially with program QWIK4 which can read either TU-10 or Kennedy tapes. Program generation for the aircraft computer is performed at LYC, so that the computer is predominantly used for program compilation, testing, and technician training.

The reader is referred to appendix 19 for the IOT's used for the LYC PDP8E.

4.1.1 OS/8 operating system

OS/8 is a sophisticated operating system designed for the PDP-8/E. Besides the monitor facilities, OS/8 includes a library of powerful system programs which allow the user to develop programs using Fortran IV and assembly language.

To bring up OS/8, the PDP8/E must be bootstrapped:

Turn the power key to the "on" position. A DECTAPE with the OS/8 operating system (see below) must be mounted on DEC tape drive unit 0, write lock, REMOTE. The switch register must then be set to 7470_8. Lower then raise the "HALT/SINGLE STEP" keys. Press "LOAD ADDR", "EXT LOAD ADDR", "CLEAR" and "CONT". The DECTAPE will spin and the terminal will respond by typing a monitor dot "."; OS/8 is running the keyboard monitor.

Any system or user program can be run from this point. At any time if a program "bombs", OS/8 can instantly be re-started by this boot proceedure. Detailed instructions on the OS/8 operating system may be found in the "OS/8 Handbook".

A list of the DECTAPES and their titles that are used on the Cloud Physics PDP8/E is given in table 4.1. The contents of each tape are included in a file on the DECTAPE and can be accessed by typing:

.DIR ↓

4.1.1 OS/8 operating system (cont'd)

TAPE NO		TITLE
1	*	SYSTEM WORK TAPE
2	*	OS/8 BACK UP
3	*	QWIK4 AND PLOT
4	*	MAINDECS DIAGNOSTICS
5	*	MORT'S TAPE
6	*	BACK UP
7	*	A/C BACK UP
8		RTX/8 DEVELOPMENT
9	*	FORTRAN IV SYSTEM
10	*	BASIC
11	*	FLAP TAPE
12		RTX/8 TAPE
13		LWC TAPE
14		FORTRAN PROGRAMS
15		TKPLOT
16		WORKING STORAGE 1
17		WORKING STORAGE 2
18		WORKING STORAGE 3
19		WORKING STORAGE 4
20	*	BACK UP

* indicates the tape contains the OS/8 operating system and can be bootstrapped

Tabe 4.1: Lab DECtape Listing

4.1.2 Centronics Printer

The line printer on the LYC PDP-8/E Computer is a Centronics 703. It is a bidirectional dot matrix printer capable of printing 180 characters per second.

The 703 is designed around the 8080A microprocessor which allows many factory options. Our printer contains the Electronic Verticle Forms Unit (EVFU) option, which should be loaded prior to device use.

An assembler program was written which will set the printer to a standard 66 lines per page. 'VFULDR' is contained on two DEC tapes which would most commonly be in use when the printer facilities are desired. Tape number 1 (system work tape) contains the source (VFULDR.PA) and core image (VFULDR.SV); tape number 9 contains just the core image. To run this program, boot up the appropriate tape and type:

<u>.R VFULDR</u>

the machine responds with:

"VFU loader
Ready printer and press return"

The printer must be turned on (left rear of machine), the paper adjusted to the top of form, then selected on line, the user may now press carriage return on the DECwriter.

The Centronics should then print:

"VFU LOADED"

4.1.2 Centronics printer (cont'd)

and the VFU led will light. VFULDR will now re-boot the OS/8 monitor.

4.2 FORTRAN IV

This chapter will describe the FORTRAN IV system available on the LYC PDP-8/E computer. The steps necessary to create and run a FORTRAN program are described in the next few sections, however it is assumed the reader has prior knowledge of FORTRAN programming.

OS/8 FORTRAN IV provides full standard ANSI FORTRAN IV under the OS/8 operating system. The FORTRAN IV package requires a hardware environment consisting of a PDP-8/E with 32k of memory, a console terminal and a mass storage device. The system is designed to employ a KE8-E Extended Arithmetic Element, FPP-8/E Floating Point Processor, and any bulk storage or peripheral I/0 device.

The FORTRAN system is highly optimized with respect to memory requirements, and an overlay feature is included that can permit programs requiring up to 300k of virtual storage. The library functions permit the user to access a number a laboratory peripherals, to evaluate a complete set of transcendental functions, to manipulate alphanumeric strings, and to output to the Tektronix graphics terminal or the calcomp incremental plotter.

4.2.1 FORTRAN system components

OS/8 FORTAN IV is a system of five programs. (table 4.2) Each program is a necessary part of the system and must be run in proper sequential order.

A. TECO - text editor
B. F4 - FORTRAN IV compiler
   1. PASS1
   2. PASS2
   3. PASS20
   4. PASS3
C. RALF - Relocatable Assembler
D. LOAD - Relocatable binary loader
E. FRTS - FORTRAN Run-time system

FIGURE 4.2: OS/8 FORTRAN IV system

A FORTRAN IV program written by the user is called a source program, to distinguish it from the various object programs generated by the OS/8 FORTRAN IV system. (see figure 4.3). Source programs are prepared on-line by means of the system editor, TECO.

4.2.1 FORTRAN system components (cont'd)

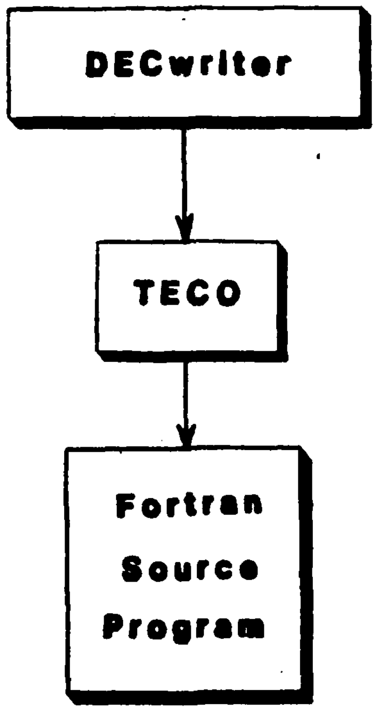


Figure 4-3: Preparing a FORTRAN IV Source File

4.2.1 FORTRAN system components (cont'd)

Once a source program has been prepared, it is supplied as input to the FORTRAN IV compiler, F4, which translates each FORTRAN statement into one or more RALF (Relocatable Assembly Language,Floating Point) statements and produces an output file containing an assembly language version of the source program.

Compilation errors are printed on the DECwriter in two letter codes. (see "OS/8 Handbook, pages 8-14 for F4 error messages). If a source listing has been requested, the errors are printed, after the line in error in plain English.

The RALF assembly language output produced by the compiler must be assembled by the *RALF assembler*. During assembly each RALF Assembly Language Statement is translated into one or more instruction for either the PDP-8/E computer or the Floating Point Processor and an output file is created containing a relocatable binary version of the assembly language input. (See figure 4.4)

The relocatable binary file produced by the RALF assembler is a machine language version of a single program or subroutine. This file, called a RALF module, must be linked with its main program (if it is a subroutine) and with any other subroutines or functions, including subroutines from the system library, that it requires in order to execute. The OS/8 FORTRAN IV loader, LOAD, accepts a list of RALF module specifications from the DECwriter and builds a loader image file containing a relocated main program linked to relocated versions of all subroutines and library components that the mainline requires to execute. (see figure 4.5)

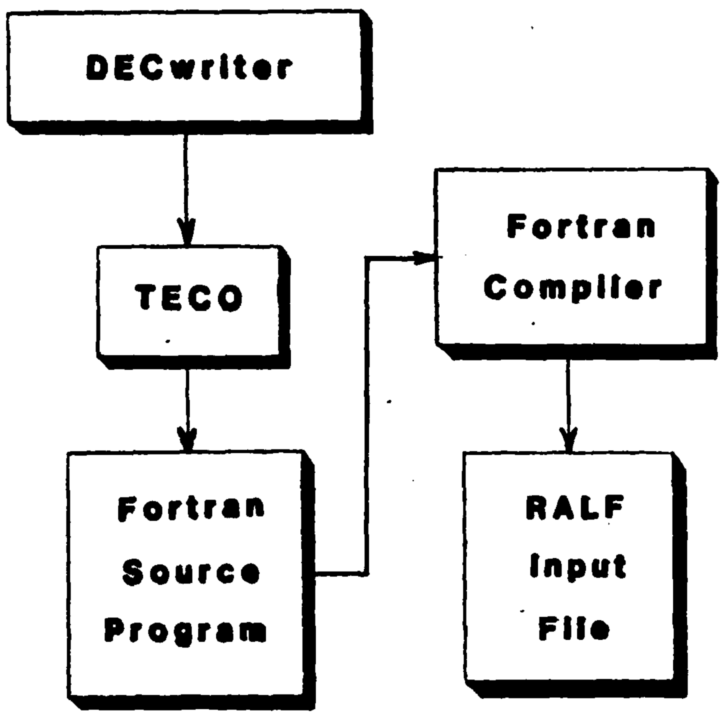


Figure 4-4: Compiling a Source File

4.2.1 FORTRAN system components (cont'd)

The loader image file is an executable core load, complete except for run-time I/O specifications. It may be saved on the DECtapes and run at any time. The loader also provides for an optional core load map that indicates memory allocation of the individual routines loaded. The overlay feature of the loader permits certain user defined modules of a program to be stored in the loader image file during execution and read into memory only as needed, which effectively provides a tenfold increase in maximum program size. (See figure 4-5)

The loader image file is read and executed by FRTS, the FORTRAN RUN-TIME SYSTEM. FRTS configures an I/O supervisor to handle any FORTRAN input or output request. The run-time system assigns I/O device handlers to the I/O unit numbers referenced by the FORTRAN program, allocates I/O buffer space, and also diagnoses certain types of run-time errors; Such as, I/O errors, numeric underflow/overflow, hardware malfunctions, etc. Run-time errors are indicated at the DECwriter; fatal errors cause the program to abort, however.

The system provides complete error traceback to identify the full sequence of FORTRAN statements that terminated in the error condition.

The compiler, assembler, loader and run-time system each accept standard OS/8 command decoder option specifications.
"OUTPUT1,OUTPUT2,OUTPUT3 < INPUT1,...,INPUT9/OPTION"

Options are alphnumeric characters preceeded by a slash. They can be anywhere in the command line, but usually placed on the right.

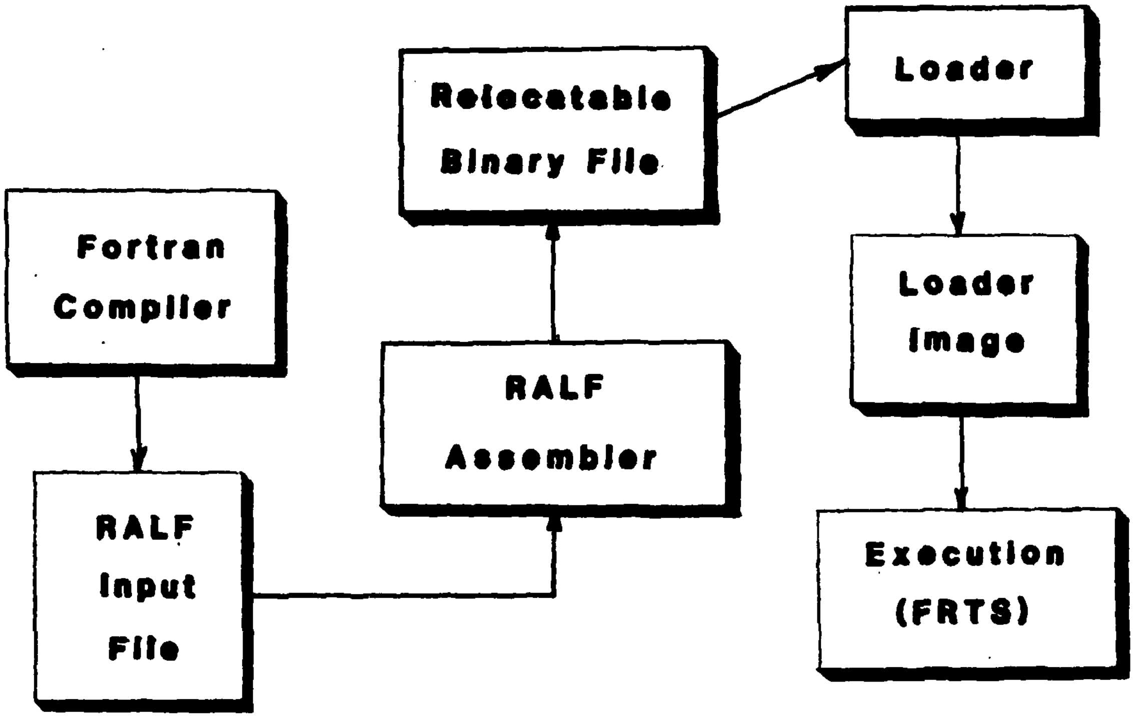


Figure 4-5: Assembling, loading and executing a RALF file

4.2.2 TECO-Text Editor

OS/8 TECO is a powerful text editing and correcting program that runs under the OS/8 operating system. TECO may be used to edit any form of ASCII text such as program listings, manuscripts, correspondence and the like. Since TECO is a character-oriented editor rather than a line editor, text edited with TECO does not have line numbers associated with it, nor is it necessary to replace an entire line of text in order to change one character.

Writing a FORTRAN program begins with the text editor. TECO is called by typing:

.R TECO ↓

and responds with an asterik "*", the OS/8 prompt. Editing with TECO is actually very simple. All commands are one or two letters with or without arguments. The following table briefly illustrates some commonly used TECO commands.

ERdev:filnam.ex	Open for <u>READ</u> (input) 'filnam.ex' on device 'dev'
EWdev:filnam.ex	Open for <u>WRITE</u> (output)'filnam.ex' on device 'dev'
Y	Clear the text buffer, then read the next page from input
P	Write the text buffer to output Read the next page from input
L	Move the character pointer (cp) to the beginning of the next line
T	Type the content of the text buffer from the cp to the beginning of the next line.
Itext	Insert mode. All subsequent characters are placed before the cp

4.2.2 TECO-text editor (cont'd)

Stext	Search for string 'text', cp positioned after search string
J	move the cp to the beginning of the text buffer
FStext1$text2$	search for sting 'text1' and replace with 'text2'
EX	write text buffer to output. copy remaining input to output, close Input/Output. exit to OS/8 monitor.

Table 4.2: TECO Command Summary

note: all commands are separated by one 'ALT MODE' key (which echos as a dollar sign) and a command string is terminated by two consecutive altmodes.

For more information regarding TECO, see the"OS/8 Handbook" pages 2-132.

4.2.3 F4 FORTRAN IV compiler

The FORTRAN IV compiler accepts one FORTRAN source language program or subroutine as input, examines each FORTRAN statement for validity, and produces a list of errors plus a RALF assembly language version of the source program, along with an optional source listing. A job which requires more than one module (i.e. subroutine) must have each program compiled separately, then combined using the loader. F4 terminates by chaining to the RALF assembler automatically unless it was requested to exit to the monitor after compilation. The compiler is called by typing:

```
.R F4↓
```

F4 responds with the Command Decoder prompt, the asterik "*". The file/option specification line is entered as:

```
dev:RALF.RL,dev:LIST.LS<dev:FTCODE.FT/(options)
```

terminated with a carriage return. The compiler accepts four options. Any run-time options recognized by RALF,LOAD or FRTS may be specified to the compiler.

OPTION	OPERATION
A	return to keyboard monitor after compilation. RALF is not called
F	produce a RALF listing on 'dev:LIST.LS'
N	do not include error traceback faciltities (decreases memory requirements)
Q	optimize cross-statement subscripting during compilation.

Table 4.3: F4 Compiler Options

4.2.3 F4 FORTRAN IV compiler (cont'd)

Any errors detected by the compiler are reported on the DECwriter in short form (see "OS/8 Handbook", pages 8-14). If a listing is requested, the errors are printed in english.

4.2.4 RALF - relocatable assembler

The RALF assembler accepts one RALF assembly language program or subroutine as input and produces a relocatable binary file, called a RALF module, as output. An optional listing of the assembled input file is also available. RALF terminates an assembly by exiting to the keyboard monitor unless it was requested to chain to the loader.

RALF honors three options:

OPTION	OPERATION
G	After assembly, chain to the loader, then to the Run-Time system
L	After assembly, chain to the loader, but not the Run-time system
T	If a listing file has been specified in the command line, surpress the listing and produce only the symbol table

Table 4.4: RALF Options

RALF is called by typing:

.R RALF↓

and responds with an asterik. The command line appears as:

dev:RALF.RL,dev:LIST.LS<dev:RALF1.RA,...,dev:RALF9.RA/(options)

4.2.4 RALF - relocatable assembler (cont'd)

If more than one Input is specified, they are combined into one module and assembled as if it were one file.

When an error is detected, the error code (see "OS/8 Handbook" pages 5-38 for RALF error codes) and the line in error are printed on the DECwriter. If a listing was requested, the error code appears before the line in error.

For more details on the RALF assembler and how to code Floating Pcint programs, see the "OS/8 Handbook", chapter 5 and pages 8-15 to 8-20.

4.2.5 LOAD - relocatable loader

The OS/8 FORTRAN IV loader accepts up to 128 RALF modules along with any necessary library components, to form a loader image file that may be loaded and executed by the run-time system. This is accomplished by replacing the relative starting location of each section (module) with an absolute core address. Absolute addresses are also assigned to all entry points defined in the input modules. Once all RALF modules and library components have been assigned to some portion of memory and linked, absolute addresses are assigned to the relocatable binary text and to the externals.

The overlay feature of the loader facilitates running programs which are too large to fit into memory, allowing programs which require 300K of memory to run in less than 32K actual core memory.

An overlay is a set of subroutines stored on a bulk storage device. When any subroutine in an overlay is called by the mainline or other subroutine, the entire overlay is read into memory, where it generally replaces another overlay of equivalent size.

Overlays are variable-size portions of memory reserved for specific sets of overlays. FORTRAN IV permits eight levels, 0-7. Level 0 is always present in memory, and contains the mainline, common blocks, PDP8 mode code, and library components.

Levels 1 thru 7 each may contain up to 16 overlays, one of which is core resident at any given time during execution.

4.2.5 LOAD - relocatable loader (cont'd)

As execution begins, overlay MAIN is loaded into level 0 and started. Other overlays are read into memory when one of their constituent subroutines is called. No two overlays from any given level are ever co-resident simultaneously.

To call the loader, type:

```
.R LOAD ↓
```

Load will respond with an asterik. The command string appears as:

```
dev:IMAGE.LD,dev:MAP.LS<dev:PROG9.RL,...,dev:PRO9.RL/(options)
```

IMAGE.LD is the loader image output file. MAP.LS is the loader symbol map outpuc file. Possible run-time options are:

OPTION	OPERATION
C	Continue the current line of input on the next line. The command decoder only permits nine input files per line. This option circumvents this.
G	Treat the current line of input as the last and chain to the run-time system.
L	Accept the single input file on this line as an alternate library, used in place of the system library.
O	Close the current level, and open the next sequential level for input.
S	If a symbol map has been requested, include system symbols.
U	Ignore the rules governing subroutine calls between overlays

TABLE 4.5: LOAD OPTIONS

4.2.6 FRTS - FORTRAN run-time system

The OS/8 FORTRAN IV run-time system reads, loads, and executes a loader image file produced by the loader. It also configures a software I/O interface between the FORTRAN IV program and the OS/8 operating system, then monitors program execution to direct I/O processes and identify certain types of run time errors. The run-time system is called automatically to load and execute the loader image file produced by the loader whenever the "G" option is specified to the loader.

The run-time system is able to accept file I/O specifications. This allows the user to write a source program which refers to an I/O device as an integer constant or variables. This program may be compiled,assembled and loaded into an image file. This image file may be run any number of times each time specifying different physical I/O devices. Thus logical unit #8 may refer to the DECwriter in one run, and the line printer in another run.

To call the run-time system, type:

```
.R FRTS↓
```

FRTS calls the command decoder and responds with an asterisk. The run-time system accepts two classes of input. (1) the load module to be executed. (2) Run-time file assignments. To define the image file, type:

```
*dev:IMAGE.LD/(options)
```

4.2.6 FRTS - FORTRAN run-time system (cont'd)

Possible options to FRTS are:

OPTION	OPERATION
H	Halt after loading, but before executing the program. Pressing 'cont' switch starts the program.
E	Ignore the following run-time errors a. Illegal subroutine call b. Reference an external in an overlay other than in the form 'JSR EXTERN' c. Reference to an undefined symbol

TABLE 4-6: Run-Time System Options

Once the image file has been defined, FRTS returns with another asterisk to accept I/0 specifications. Four out of nine possible I/0 unit numbers are initially assigned by FRTS.

I/0 UNIT	INTERNAL HANDLER
1	paper tape reader
2	paper tape punch
3	line printer
4	DECwriter
5	
6	
7	user defined
8	
9	

TABLE 4-7: FORTRAN I/0 Unit Assignment

To associate a device with a unit number type:

```
dev:/n
```

where "n" is the unit number, and "dev:" is any name of a non-directory device (LPT:,MTA0:)

4.2.6 FRTS - FORTRAN run-time system (cont'd)

To define a file structured data file type:

dev:file.ex/n for previously created files
dev:file.ex</n for non-existeant files.

In any case, only one file or device specification is permitted on each line, and no more than six directory devices files may be created by the Fortran program. A specification terminated with an ALTMODE starts the Fortran program.

4.3 Post Flight Processing

The post mission data reduction system is a series of programs which read PMS 1D or PDP-8/E flight magtapes and perform various lookup and display options. Specific time intervals may be retrieved. These programs are used on site for a preliminary data analysis prior to (and sometimes instead of) processing on the AFGL CDC 6600 mainframe. Some programs were written in PDP8 assembler and others in FORTRAN IV.

4.3.1 Programs written in Assembler language

4.3.1.1 Program QWIK4

QWIK4 performs a quick look type dump for all 1D PMS and PDP8 data tapes from the MC130E. The dump printed by the program includes time printouts, raw and calibrated VCO's, total probe counts, and certain values derived from this data.

The program may be run in two different modes. The first mode dumps the entire tape printing averages over a specified interval. The second mode allows flight time or elapsed time to be used to locate a record. This feature will be useful in locating the start of a sampling run or any time interval of interest

Operating instructions

Mount the magtape to be dumped on unit 0 with the write enable ring removed to prevent any possible corruption of data.

Turn on the GE Terminet printer, press the 'ON LINE' button and be sure that the paper is free to feed.

Respond to the OS/8 dot (.) by typing "R QWIK4" (return)

When QWIK4 is started it will print

```
QUICK-LOOK PROGRAM
FLIGHT TAPE (F) OR KENNEDY TAPE (K)?
```

Respond by typing F if the magtape is a PDP8 generated flight tape of K if the tape is from Kennedy tape recorder in

4.3.1.1 Program QWIK4 (cont'd)

the PMS system. Terminate input with a return.

NOTE: all inputs to QWIK4 are terminated with a return.

FLIGHT NO.,DATE?

Enter the flight number and date or a string of up to 30 characters which identifies the tape. The program then asks

ALL (A) OR SPECIFIED (S) TIMES?

Respond with A to dump the whole tape starting at the tape head's current location. The program will not rewind the tape to the load point before dumping. This is useful if the program fails to locate a specified time interval. The operator may position the tape to the approximate time desired using the off line controls on the TU-10. The A option may then be used to determine what was recorded on the tape. There is one small problem associated with this procedure. When the off line controls are used to forward space or backspace the tape, the TU-10 does not stop on an even record boundary. Therefore the first few seconds of data produced by the program should be ignored if the tape has been moved with the off-line controls. The program will detect this error condition and print

!!!INCORRECT MAGTAPE RECORD LENGTH!!!

This printout is normal after the tape has been moved with

4.3.1.1 Program QWIK4 (cont'd)

the off-line controls, however it should only print once. The first read done by the TU-10 will reposition the tape head to the beginning of a record and subsequent records should be readable without generating this error. If this printout repeats continuously,the tape is not in the correct format and any results printed by the program will be incorrect.

The S option allows the operator to specify a time interval on the tape to be dumped. If this option is selected the program then prints

CLOCK (C) OR ELEAPSED (E) TIME?

Type C to use the flight time clock to look up records or E to use the PMS buffer elapsed time. The program will attempt to find the specified time interval no matter where it is on the tape and will minimize tape motion as much as possible. If the tape has gone beyond the time interval desired the program will backspace as necessary to rewind the tape to the load point before each run.

After the operator has specified which clock to use the program will print

START TIME

Respond by typing the starting time for the dump in the form SSSS to specify a four digit elapsed time in seconds or

4.3.1.1 Program QWIK4 (cont'd)

HH:MM:SS to specify a flight time. The program will then print

STOP TIME

Respond with the stop time in the same form used for the start time

The program now asks

AVERAGING INTERVAL (SECS)

This question is printed for both the specified time interval and dump all times mode. Respond with the number of seconds to be shown in each printout.

The program then begins calculating averages over the specified time interval and printing a report for each interval. Contained in each printout are the start and stop flight and elapsed times for that interval, average VCO values, average values of parameters derived from the VCO's and total probe counts.

Some sample printout is contained in figure 4.5.

The program may be restarted from the beginning by setting the switches to 0200 and pressing HALT, ADDR LOAD, EXT ADDR, LOAD, CLEAR, CONTINUE.

```
QUICK-LOOK PROGRAM

FLIGHT TAPE (F) OR KENNEDY TAPE (K)? K
A OR E? E
FLIGHT NO., DATE? E76-06    E76-\\\\30 JAN 76
ALL (A) OR SPECIFIED (S) TIME? S
CLOCK (C) OR ELAPSED (E) TIME? E
START TIME  555
STOP  TIME  555
AVERAGING INTERVAL (SECS)  1

*****************************************************************************
                                   *                  *
                                   *  QUICK-LOOK DUMP *
                                   *   C130E  PMS1D   *
                                   *                  *
                                   ********************

FLIGHT INFORMATION                        1  SECOND AVERAGE
                                           AIRCRAFT TIME          ELAPSED TIME
E76-06   30 JAN 76                     START          STOP      START   STOP
                                       22:59:14    22:59:14      555     555

VCO                   RAW     CONVERTED                   TOTAL  PROBE  COUNTS

DELTA PRESS          3956    -44.276 (MB)              CHANNEL       SC     CL    PR
TEMPERATURE          3247    -17.609 (DEG C)
PRESSURE             7775    742.737 (MB)                    1        7      0    47
DEWPOINT             2699    -21.454 (DEG C)                 2        4      0    83
LWC/JW               4969      6.278 (G/M**3)                3        8      0    27
MAG HEADING          1748    117.201 (DEG)                   4        2      0     1
                                                             5        2      0     0
                                                             6        2      0     0
HEIGHT               8336.34 (FEET)                          7        3      1     0
IND  AIRSPEED         -49.31 (KNOTS)                         8        1      0     0
TRUE AIRSPEED         185.27 (KNOTS)                         9        1      0     0
TRUE TEMP             -13.10 (DEG C)                        10        0      0     0
                                                            11        1      0     0
                                                            12        3      0     0
                                                            13        2      0     0
                                                            14        1      1     0
                                                            15        0      0     0


**END OF TIME INTERVAL**
ALL (A) OR SPECIFIED (S) TIME?
```

Figure 4.5: Program QWIK4 Sample Output

4.3.1.1 Program QWIK4 (cont'd)

Alternatively the program can be restarted from the "ALL (A) OR SPECIFIED (S) TIMES?" question by setting the switches to 0000 and pressing HALT, ADDR LOAD, EXT ADDR LOAD, CLEAR, CONTINUE.

4.3.1.1 Program QWIK4 (cont'd)

The following error messages may print out during execution of QWIK4.

printout	possible cause(s)	recommended action(s)
TIME INTERVAL OUT OF RANGE	time specified not on tape	use "A" option to see what is on tape
END OF TAPE	time specified not on tape	rewind tape and try another time interval
!!!MAGTAPE PARITY ERROR!!!	bad tape, bad TU10	try another tape;if the printout is infrequent it may be ignored;however if data looks bad this is the cause
!!!INCORRECT MAGTAPE RECORD LENGTH!!!	bad tape (unlikely), question asking if tape was Kennedy tape (PMS) or Flight tape (PDP8) was answered incorrectly tape head was not on even record boundary due to operator moving it using off-line controls	try another tape;restart program at 0200 and answer question correctly no action necessary simply ignore results of first averaging interval

Some errors will not be detected by the program. Following is a list of the conditions and recommended actions.

disposition	possible causes(s)	recommended action(s)
TU10 "rocks" and will not locate time specified	bad times on tape	use "A" option to dump tape
program will not load	bad system tape unknown	try backup system tape notify DPSI
program "hangs up"	unknown	record AC, PC, MQ and notify DPSI
program halts	unknown	record AC, PC, MQ and notify DPSI

Table 4.8: QWIK4 errors

4.3.1.2 Program KNMON

Program KNMON was written for testing and verification of the PMS-1D interface. It also allows the associated M1703 card to be checked out. Any desired channel selected by the operator may be monitored. Every second the PMS-1D system sends 64 four digit words to the computer. Actually the PDP-8E receives its data one digit at a time in 1/256 second intervals. However it takes one second for the 64 words to become available. Each second the value of the selected channel is printed. Refer to appendix 8 for the table of PMS channels.

To operate the program

1. Respond to the OS/8 dot by typing "R KNMON (return)

2. After KNMON is started it will print

   KN CHANNEL

Respond by typing the Knollenberg channel to monitor (from 1 to 64) followed by return.

3. To select another channels set SR to 0200 and press 'HALT', 'LOAD ADDRESS', 'EXTD ADDR LOAD', 'CLEAR', 'CONTINUE' then continue from step 2.

4.3.1.3 Program PLOT

Program PLOT was written for calibration and general plotting at LYC. A modified version has also been generated for use on the airplane with input on the Tektronix keyboard and output on the CRT and GE printer.

Program PLOT will

(a) plot an x-y table on the Tektronix plotter; the table is inputted at the Decwriter. If desired, the x and/or y values can be modified by logging them in order to produce a linear-linear, a linear-log, a log-linear or a log-log plot.
(b) generate the x values automatically after a specification of the first x and x-step is given
(c) allow the user to select the low and high values of x and y to be used on the plot
(d) plot each point with +; the user can choose whether or not to connect the plotted points with a line
(e) label the plot with an alphabetic description
(f) plot a least square best fit curve to the data (first or second degree), and print out the fitting function
(g) generate a table of deviations of the least square fit to the original data, and calculate the RMS error
(h) allow the user to modify the data, limits and descriptions and replot, with a new least square fit, without having to retype the entire x-y table.

4.3.1.3 Program PLOT (cont'd)

In order to execute program PLOT, and perform the many optional capabilities, the following step-by-step procedure should be executed:

1. Mount Dectape 136 on unit 0, write enabled and remote
2. Switches set to 7470
3. Press Addr-load, Ext.-addr-load, Clear, Cont
4. Computer responds with a dot
5. Type R PLOT
6. Within 22 seconds the computer responds with
   PLOTTING PROGRAM
7. IS X ON LOG SCALE?
   If the x-data is to be logged base 10, answer Y otherwise N
8. IS Y ON LOG SCALE?
   If the y-data is to be logged base 10, answer Y otherwise N
9. IS DELTA X CONSTANT?
   If the x-data (before taking logs) is equally spaced, answer Y, otherwise N
10. If delta x is constant, the computer will request X-START and DELTA-X, as X-START?
    Type the starting value and return,
    DELTA-X?
    Type the difference between successive x-values and return
11. The computer responds with
    ENTER X,Y TABLE
    or ENTER Y TABLE (for constant delta-x)

4.3.1.3 Program PLOT (cont'd)

12. For each value input the computer will first print the index number (1,2,3,...etc) If only y-values are being inputted, the user will type the y-value followed by a return; if both x and y values are being inputted, the user will type the x-value, followed by a comma, followed by the y-value and a return.
13. When all values have been inputted, type

    1E35 return

14. The computer will respond with

    LIMITS OF X ARE xxxxx, xxxxx

    which indicate the low and high values of the x-table. Then it prints

    TYPE LIMITS TO USE

    The computer expects two numbers, separated by a comma, the first number is the value of x at the left end of the plot; the second is the value of x at the right end of the plot. There will automatically be 10 divisions in this range. If the first limit typed is unacceptable (larger than the limit found) or if the second limit typed (smaller than the limit found) is unacceptable, step 14 is repeated.
15. Step 14 is done for Y
16. The computer will print

    CONNECTING LINE?

    If a line is desired between points in the order they were typed in, answer Y. An answer of N will eliminate the connecting line.
17. The computer will respond

    TURN ON PLOTTER, TYPE DESCRIPTION

    Type a description to be printed on the bottom of the

4.3.1.3 Program PLOT (cont'd)

plot. This description is limited to 67 characters. A rubout will respond with a carriage return, and the user should type the entire description over again.
Make sure plotter is on, and "on-line" before pressing return.

18. The plot will be made. At its conclusion, the computer will ask

    LEAST SQUARE FIT?

    If a curve fitting the data is desired answer Y; otherwise answer N and proceed to step 22.

19. The computer responds

    DEGREE(1 OR 2)?

    Degree 1 is a straight line fit; degree 2 is a quadratic fit. Respond either 1 or 2. Any other response will force step 19 again.

20. The fitting curve will be plotted. The least square polynomial will be printed

    (a) at the top of the plot, and
    (b) on the Decwriter

21. The computer then asks

    DEVIATIONS?

    If the table of x, y, calculated-y, deviation-y and RMS is desired, answer Y; otherwise answer N

22. The computer will ask

    REPLOT?

    If the data is to be modified, eliminated, or extended, or if another plot is to be made changing either x or y limits, or the description, or the fitting function, respond with Y; otherwise respond N and proceed at step 6

4.3.1.3 Program PLOT (cont'd)

23. The computer will ask

    NUMBER?

    If there are no changes go to step 23(c).

    (a) The computer expects the index number of the data point being changed. It will accept an index number one greater than the length of the table (omit the number corresponding to 1E35) with the assumption that the table is being extended. The table may be extended repeatedly by entering an index number equal to one more than the previous maximum number. If the number typed is invalid, step 23 is repeated. After the number is accepted, the computer will type X,Y =

        Respond with the value of x, a comma, the value of y and return. Step 23 will be repeated. The data being typed will be logged according to responses made in steps 7,8

        CAUTION: DO NOT ENTER 1E35 FOR THE LAST NUMBER. The program knows how many points there are in the table.

    (b) If a value of x,y is to be eliminated, after its index number has been accepted, and X,Y = has printed, type

        1E35,1E35 return

    (c) When all changes have been made, answer NUMBER? with 0 return

        The procedure restarts at step 14

4.3.1.3 Program PLOT (cont'd)

ERRORS

1. Alphabetic errors: If an error is discovered before return is pressed, and the information was alphabetic, as in steps 7,8,9,16,17,18,19,21,22, type the rubout key; the computer will respond with a carriage return; retype the entire response, beginning with the first character.

2. Numeric errors: If an error is discovered before a comma or return is pressed, and the information was a number, as in steps 10,12,14 and 23, type the rubout key; the computer will not respond (automatic feature of the 27 bit floating point package); then type the entire number over again, beginning with the first character. CAUTION: If two numbers were being inputted, separated by a comma, the rubout will erase the CURRENT NUMBER ONLY.

3. Incorrect responses to Y or N: The computer will specifically look for the Y. Any character other than Y will be treated as N except a carriage return, which should be used only after a character has been typed.

RESTART ADDRESS: 0200

4.3.1.4 Program HSKPNG

HSKPNG will dump PMS 1D housekeeping information to the GE Terminet printer onboard the MC130E aircraft. To run, type: .R HSKPNG

The following message will appear on the Tektronix screen

"HSKPNG--1D HOUSEKEEPING DUMP"
"SET SR, HIT CONT"
"SW0=A, SW1=D, SW2=P"

1. Either one or two probes may be selected by raising the appropriate switches. To dump the

   Axial scatter probe set switch 0
   Cloud droplet probe set switch 1
   Precipitation probe set switch 2

   After probe selection press the 'CONTINUE' switch. If the TU-10 isn't at load point, the tape will be rewound.

2. "START TIME-"

   Enter:
   A) <CR> to dump entire tape OR
   B) HH:MM <CR> to start the dump at a specific time.
   (NOTE: IF INPUT TIME IS PRE FLIGHT,
   "*** TAPE STARTS AT HH:MM ***" WILL PRINT, AND
   YOU'LL BE ASKED START TIME AGAIN.)

4.3.1.4 Program HSKPNG (cont'd)

3. "STOP TIME-"

If you entered <CR> for start time, this question will be omitted.

Enter:

A) <CR> for no stop time. (DUMP TO END OF FILE) OR

B) HH:MM <CR> to stop the dump at a specific time (NOTE: IF THIS TIME IS PAST THE END OF FILE, AN ERROR MESSAGE WILL PRINT AT THE END OF FILE. IF THERE IS NO END OF FILE, YOU WILL NOTICE THE TAPE ADVANCING TO END OF TAPE.)
When the tape reaches the stop time, "END OF INTERVAL" will be printed, and you'll be asked 'START TIME-' again.

At any time, switch 11 on the switch register may be flipped up to suppress line printer output and then send real time and eleapsed time to the Tektronix screen. This can be used to omit certain data from the output. Setting switch 11 back to a 0 (down) resumes line printer output.

TU-10 ERRORS

If the TU-10 encounters an error while reading, a tape error message will be printed on the screen. The TU-10 error number will be stored in the AC, and the program will halt. Press continue to resume operation.

4.3.1.4 Program HSKPNG (cont'd)

Possible error messages are:

PARITY ERROR
END OF FILE
END OF TAPE
INCORRECT RECORD LENGTH

ERROR NUMBERS

BIT	ERROR
0	ERROR FLAG
1	TAPE REWINDING
2	BOT
3	SELECT REMOTE
4	PARITY ERROR
5	EOF
6	INCORRECT RECORD LENGTH
7	DATA REQUEST LATE
8	EOT
9	FILE PROTECT
10	READ COMPARE ERROR
11	ILLEGAL FUNCTION

COLUMN HEADINGS

	AXIAL		DROP & PRECIP
+15S	+15v. supply voltage	+15S	+15v. supply voltage
PTMP	probe temperature	MTMP	mirror temperature
SIZE	size range selected	EL01	element 1 voltage
REFV	laser ref. voltage	EL24	element 24 voltage
-15S	-15v. supply voltage	-15S	-15v. supply voltage
ETMP	electronics temp.	5tmp	+5v. supply temp.
+5S	+5v. supply voltage	+5S	+5v. supply voltage
5TMP	+5v. supply temp.	ELRT	electronic temp
+15S	+15v. supply voltage	+15S	+15v. supply voltage
PTMP	Probe temp.	MTMP	mirror temp

		+15C	FTMP			+15S	ETMP	+5S	STMP	+15S	FTMP
000	19:32:03	[illegible]	[illegible]	[illegible]	4933	2198	0556	.0109	2029	4744	0531
		0555	.0109	2029	4749	0531	2337	.4931	2181	0555	0109
010	19:32:19	0555	.0109	2029	4756	0531	2340	.4930	2171	0555	0108
		0555	.0109	2028	4753	0531	2336	.4930	2159	0555	0109
030	19:32:39	0555	.0108	2029	4759	0531	2335	.4930	2147	0555	0108
		0555	.0108	2029	4774	0531	2334	.4930	2136	0555	0107
050	19:32:59	0555	.0108	2029	4775	0531	2328	.4930	2124	0555	0108
		0555	.0107	2029	4781	0531	2320	.4931	2112	0555	0107
070	19:33:19	0555	.0107	2029	4786	0531	2321	.4930	2102	0555	0107
		0555	.0106	2029	4784	0531	2317	.4931	2090	0555	0107
090	19:33:39	0555	.0106	2029	4785	0531	2314	.4930	2080	0555	0106
		0555	.0106	2029	4793	0530	2311	.4931	2068	0555	0106
110	19:33:59	0555	.0106	2029	4794	0531	2309	.4930	2059	0555	0105
		0555	.0106	2029	4797	0531	2304	.4931	2049	0555	0105
130	19:34:19	0555	.0105	2029	4801	0531	2300	.4931	2039	0555	0105
		0555	.0105	2029	4805	0530	2298	.4930	2027	0555	0105
150	19:34:39	0555	.0104	2029	4809	0530	2294	.4931	2016	0555	0105
		0555	.0104	2029	4811	0531	2291	.4931	2005	0555	0104
170	19:34:59	0555	.0104	2029	4811	0531	2288	.4931	0996	0555	0104
		0555	.0103	2029	4814	1531	2284	.4933	0985	0555	0103
190	19:35:19	0555	.0104	2029	4810	0531	2281	.4931	0976	0555	0104
		0554	.0104	2029	4815	0531	2277	.4932	0967	1555	0103
210	19:35:39	0555	.0102	2030	4824	0530	2276	.4931	0958	0555	0102
		1555	.0103	2029	4825	0531	2271	.4932	0948	0555	0102
230	19:35:59	1555	.0102	2030	4827	0531	2268	.4932	0939	0555	0102
		1555	.0102	2029	4837	1531	2264	.4932	0930	0555	0102
250	19:36:19	1555	.0102	2029	4832	1531	2261	.4932	0921	1555	0102
		1555	.0101	2030	4835	1531	2258	.4932	0912	1556	0101
270	19:36:39	1555	.0101	2030	4845	0531	2256	.4932	0904	1555	0101
		1555	.0101	2030	4843	-1531	-2252	.4933	-0895	1555	0101
290	19:36:59	1556	.0100	2030	4854	1531	2250	.4933	0887	1555	0101
		1555	.0101	2030	4849	1532	2246	.4935	0878	1556	0100
310	19:37:19	0556	.0100	2031	4860	1532	2243	.4936	0870	1555	0101
		1556	.0100	2031	4865	1532	2241	.4936	0862	1556	0100
330	19:37:39	0556	.0100	2032	4869	1532	2238	.4938	0859	1556	0100
		1557	.0099	2032	4874	1533	2235	.4939	0847	1556	0100
350	19:37:59	1557	.0099	2033	4880	1533	2233	.4940	0839	1557	0099
		1557	.0100	2033	4877	1534	2230	.4941	0831	1558	0099
370	19:38:19	1557	.0099	2034	4890	1534	2227	.4942	0824	1556	0099
		1558	.0098	2034	4885	1534	2225	.4943	0817	1558	0099
390	19:38:39	1558	.0099	2034	4895	1534	2222	.4945	0809	1558	0099
		1558	.0099	2035	4905	1535	2218	.4946	0803	1558	0099
410	19:38:59	1559	.0098	2035	4903	1535	2217	.4947	1795	1579	0098
		1559	.0098	2036	4911	1535	2214	.4949	1788	1559	0098
430	19:39:19	1560	.0098	2036	4915	1536	2210	.4950	1781	1560	0098
		1560	.0098	2036	4910	1536	2208	.4951	1773	1561	0098
450	19:39:39	1560	.0099	2037	4923	1537	2205	.4952	1767	1560	0099
		1560	.0099	2036	4930	1536	2203	.4952	1761	1560	0099
470	19:39:59	1561	.0099	2036	4930	1537	2200	.4953	1754	1561	0099
		1562	.0099	2036	4931	1537	2197	.4955	1747	1562	0099
490	19:40:19	15[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1741	1561	0100
		15[illegible]							1735	1561	0101
510	19:40:39	15[illegible]							1728	1562	0101
		1562	.0101	2040	4967	1538	2186	.4959	1722	1562	0101
530	19:40:59	1562	.0101	2041	4973	1539	2184	.4960	1725	1563	0101
		1563	.0102	2041	4975	1539	2181	.4961	1720	1563	0101

4.3.1.4 Program HSKPNG output

4.3.2 Programs written in Fortran IV

4.3.2.1 KNOL1D

Introduction

KNOL1D is a PDP8/E Fortran IV program which has been developed for the Cloud Physics Branch to obtain quick and informative printer display of aircraft data from the lab PDP8/E computer.

KNOL1D will accept an input tape from either the PMS 1D Kennedy recorder or the PDP8/E TU-10 flight tape. The output device is the line printer and an example may be found in figure 4.6. Note however, the example contains one 'block' of data, whereas, KNOL1D prints two per page.

Operation

The KNOL1D program is currently stored on the "Fortran System" DECtape (#9), the source code is on tape 14, "Fortran programs". To run KNOL1D, tape #9 must be mounted on unit 0 and the operating system booted up. The TU-10 or Kennedy tape should be mounted on the magtape drive, set to unit 0 and on-line. In response to the OS/8 monitor dot on the DECwriter, type 'EXECUTE KNOL1D.LD'. FRTS will load and start running KNOL1D.

KNOL1D begins by asking a battery of questions:

4.3.2.1 KNOL1D (cont'd)

"PDP-8/E KNOL1D VX.YY"

1 "FLIGHT NUMBER?"
THE FLIGHT NUMBER IS ENTERED IN THE FORM "EYY-NN"

2 "TAPE FORMAT?
0 - PMS
1 - TU-10 (RAWINS)
2 - TU-10 (FPPINS)
3 - TU-10 (SEMI-INS)"
THE TAPE FORMAT MAY BE PMS OR TU-10 (SELF EXPLANATORY), RAWINS IS FOR TAPES WITH INS FORMATTED LAT/LON. FPPINS IS DATA CONVERTED TO FORTRAN FLOATING-POINT, SEMI-INS IS THE CURRENT FORMAT AND CONTAINS LAT/LON IN BINARY FORMAT-ADJUST FORM.

3 "A-D BUFFER?
0 = NEW (> APRIL 80)
1 = OLD (< APRIL 80)"
IN APRIL 1980 THE A-D BUFFER FORMAT WAS CHANGED. FLIGHTS BEFORE APRIL 1980 ARE #0, OTHERWISE #1.

4 "FLIGHT DATE?"
THE FLIGHT DATE IS ENTERED IN THE FORM "DD-MMM-YY"

5 "MAG HEADING DEVIATION = 0.0, CHANGE?"
THE MAGNETIC DEVIATION IS PRESET TO ZERO AND MAY BE MANUALLY CHANGED TO ACCOMODATE FLIGHTS IN AN INFINITE RANGE OF LATITUDES AND LONGITUDES. AN ANSWER OF "Y" RESPONDS WITH:

4.3.2.1 KNOL1D (cont'd)

6 "CHANGE TO?"
THE USER NOW ENTERS THE NEW MAGNETIC DEVIATION IN DEGREES.

7 "AVERAGING INTERVAL IN SECONDS?"
THE NUMBER OF SECONDS TO AVERAGE PER BLOCK OF DATA (i.e. 60 SECOND AVERAGE).

8 "START,STOP TIMES (AS 'HHMMSS HHMMSS')?"
ENTER START AND STOP TIMES AS INDICATED. TO PROCESS AN ENTIRE TAPE TYPE: "000000 999999".

9 "PARTICLE TYPE: HARDWARE INPUT OK?"
IF HARDWARE INPUT OF PARTICLE TYPE (ONLY TU-10 FLIGHT TAPES) FROM THE C130 EVENT SWITCHES IS DESIRED, TYPE "Y", OTHERWISE MANUAL RESPONSE IS NECESSARY, AND ...

10 "PARTICLE TYPE (1,2,3,4,5)?"
ENTER THE NUMBER 1-5 CORRESPONDING THE APPROPRIATE WEATHER CONDITIONS.
1 = RAIN (DEFAULT FOR PMS TAPES)
2 = WET SNOW
3 = SMALL SNOW
4 = LARGE SNOW
5 = BULLET-ROSETTES

11 "COMMENTS?"
TWENTY-FOUR CHARACTERS ARE RESERVED FOR ADDITIONAL USER COMMENTS

4.3.2.1 KNOL1D (cont'd)

TAPE errors are reported on the DECwriter terminal, and could be parity errors, incorrect record length and end of tape/file. When KNOL1D has reached the stop time, it will return to question 8.

4.3.2.1 KNOL1D (cont'd)

A FLIGHT ID
FLIGHT DATE
INITIAL AIRCRAFT AND ELAPSED SECONDS
DATA AVERAGING CYCLE
COMMENTS

B INITIAL LATITUDE AND LONGITUDE

C PARTICLE TYPE; HARDWARE OR USER INPUT

D AVERAGED VCO'S; RAW AND CALIBRATED

E SUMMED SCATTER, CLOUD AND PRECIP PROBE COUNTS

F PROBE CHANNEL SIZES
NUMBER/METERS**3 - MM BANDWIDTH

G SCATTER, CLOUD AND PRECIP PROBE HOUSEKEEPING STATUS WORDS

H VARIOUS SELECTED PARAMETERS

Figure 4.6A: KNOL1D.FT sample output section definitions

FLIGHT E79-28 DATE 28-MAY-79 (A) 2:59:58 ESEC 0
*** FINAL *** 60 SECOND INTERVAL

LAT (B) 42 13 05 NORTH
LON 71 54 33 EAST

PARTICLE TYPE: RAIN (C)

CH#	VCO LABEL	RAW	CALIBRATED		PROBE COUNTS SCATTER	CLOUD	PRECIP
1	T A S	5148	64.8	KNOTS	21	0	0
2	TOTAL TEMP	5963	8.8	DEG C	4	0	0
3	EWER	64	64.0	COUNTS	4	0	0
4	TWCI (TMP2)	0	0.0	COUNTS	1	0	0
5	DEW POINT	4315	-6.0	DEG C	0	0	0
6	J/W LWC	4974	-0.1	G/M^3	0	0	0
7	MAG HEADING	2836	77.9	DEG	0	0	0
8	PRESSURE	1403	994.8	MB	0	0	0
9	T A S	3665	133.2	KNOTS	0	0	0
10	ICE DETECTOR	0	0.0	COUNTS	0	0	0
11	TWCI (CTR1)	0	0.0	COUNTS	0	0	0
12	TWCI (TMP1)	0	0.0	DEG C	0	0	0
13	TWCI (CTR2)	0	0.0	COUNTS	0	0	0
14	DELTA P	5143	7.9	MB	0	0	0
15					0	0	0
16							0

NUMBER - DENSITY (N/VOL/UM)

SIZE	SCATTER	SIZE	CLOUD	SIZE	PRECIP
3	4.7E+06	24	0.0E-01	351	0.0E-01
5	4.5E+05	44	0.0E-01	648	0.0E-01
7	3.0E+05	63	0.0E-01	945	0.0E-01
9	5.6E+04	83	0.0E-01	1242	0.0E-01
11	0.0E-01	103	0.0E-01	1539	0.0E-01
13	0.0E-01	123	0.0E-01	1837	0.0E-01
15	0.0E-01	143	0.0E-01	2133	0.0E-01
17	0.0E-01	162	0.0E-01	2430	0.0E-01
19	0.0E-01	182	0.0E-01	2728	0.0E-01
21	0.0E-01	202	0.0E-01	3025	0.0E-01
23	0.0E-01	222	0.0E-01	3322	0.0E-01
25	0.0E-01	242	0.0E-01	3619	0.0E-01
27	0.0E-01	261	0.0E-01	3916	0.0E-01
29	0.0E-01	281	0.0E-01	4212	0.0E-01
31	0.0E-01	301	0.0E-01	4509	0.0E-01
(N/VOL)	1.1E+04		0.0E-01		0.0E-01

PROBE HOUSEKEEPING

	+15S	PTMP	SIZE	REFV	-15S	ETMP	+5VS	5TMP	+15S	PTMP
SCA	471	223	2024	6698	523	2072	4027	15	470	223

	+15S	MTMP	EL01	EL24	-15S	5TMP	+5VS	ELRT	+15S	MTMP
CLD	1491	2465	780	381	1519	2804	4886	3699	1489	2468
PRE	1498	277	1852	1249	1520	2636	4992	2661	1498	278

LWC	0.00E-01	G/M^3			
Z	0.00E-01	N/A			
TWCI	0.00	N/A			
WIND	0.00	DEG	COURSE	0.0	DEG
	0.00	KNOTS	GNDSPD	0.0	KNOTS
T A S	69.43	KNOTS	T A S	35.71	M/S
HEIGHT	506.25	FEET			
TRUE T	8.12	DEG C			

Figure 4.6: Sample KNOL1D output

4.3.2.2 Program KN1UTL

Introduction

A PDP8/E Fortran program was written during this contract period, and can generate line printer output of RAW tape data. Program KN1UTL will read a flight or PMS 1D magtape and dump user selected areas of the Knollenberg buffer.

KN1UTL accepts user input from the DECwriter terminal as to which type of tape to process and what area of the tape to list. Currently, KN1UTL will process either a PMS 1D tape or a TU-10 flight tape (in any of three formats: RAWINS, FPPINS, SEMINS), and dump VCO, scatter probe, cloud probe or precip probe data.

Operation

The source of KN1UTL is stored on DECtape 14; the image file is on tape 9. To run KN1UTL mount tape 9 on unit 0, write enable, boot-up the OS/8 monitor and type 'EXECUTE KN1UTL.LD'. FRTS will load and start running KN1UTL, which will respond by identifying itself:

"K N 1 U T L   V X.YY
FLIGHT ID/DATE?"

where the user enters the flight ID and data in a 78 character alpha-numeric field. Next the tape type is defined:

4.3.2.2 Program KN1UTL (cont'd)

"TAPE FORMAT?
0 = PMS 1 = TU-10 (RAWINS) 2 = TU-10 (FPPINS)
3 = TU-10 (SEMINS)"

respond by entering the one digit which corresponds to the tape mounted on the TU-10 drive.

"A TO D BUFFER?
0 = OLD; 1 = NEW"

If the tape is a TU-10 tape, the A-D buffer type must be defined. Enter 0 if the flight is before APRIL 1980, and a 1 if it is after APRIL 1980. Finally the option parameter is entered:

"OPTION?
1 = VCO 2 = SCA 3 = CLD 4 = PRE"

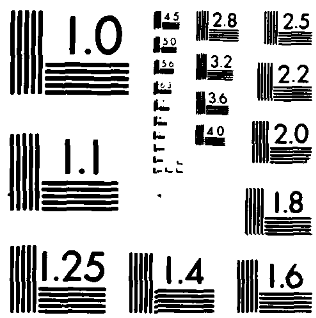
Enter the number 1-4 to indicate the Knollenberg buffer section desired.

Selected data will now be printed on the Centronix printer in paginal form, with a heading appearing at the top of each page.

AD-A109 929 DIGITAL PROGRAMMING SERVICES INC WALTHAM MASS F/G 4/2
DEVELOPMENT AND APPLICATIONS OF TECHNIQUES TO PROCESS HYDROMETE--ETC(U)
JUL 81 L E BELKSY, F B KAPLAN, J P LALLY F19628-78-C-0131

UNCLASSIFIED AFGL-TR-81-0261 NL

END
DATE
FILMED
-82
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

4.3.2.3 JWPLOT.FT

One of the liquid water content measurement systems used by Cloud Physics' onboard the MC130E aircraft is known as the "JW" (Johnson and Williams). While the device is a good means of measuring LWC, it has problems. As aircraft pitch changes during climbs and decents, it will produce values below zero. DPSI has developed a program (JWPLOT) run on the CDC computer which will correct JW data on the Tektronix CRT. The problem with this correction process is the time required to correct one flight, approximately one hour per plot. Two plots are generated per flight. The CDC computer has only two Tektronix CRT's, each having a twenty minute time limit. This makes JWPLOT unfiar to other users. A new version of JWPLOT has been developed to run on the PDP8/E computer. It was taken directly from the CDC version and modified where necessary to operate under DEC FORTRAN IV.

Running JWPLOT is a little different than other Fortran programs in that it requires a DECtape data file. The data file tape must initially be zeroed. This is accomplished through PIP. With tape #9 on unit 0, and the data file tape on unit 1, write enable, type:

```
.R PIP↓
* A:</Z$  (ALTMODE  PRODUCES DOLLAR SIGN)
.
```

The tape on unit 1 is now zeroed. Type

```
.R FRTS↓
*JWPLOT↓
*A:JWPLOT.DF</8$ (ALTMODE)
```

4.3.2.3 JWPLOT.FT (cont'd)

This generates a data file on unit 1 called JWPLOT.DF. On the following pages is a JWPLOT dialogue and sample plots.

The PDP8/E JWPLOT program is constructed from eleven programs.

JWPLOT	main code
CORE	memory device buffer
RMTA0	PMS tape processor
TEKLIB	Tektronix library
CONTIM	seconds to H:M:S subroutine
INPUT	accepts start/stop times flight ID/date
DISPL	displays plot area
JWCORR	JW correction subroutine
SCALE	scales x,y coordinates to plot area
READT	returns one second of JW/ALT data per call
LINEAX	draws x or y line axis

JWPLOT, CONTIM, INPUT, DISPL, JWCORR, SCALE and READT are taken directly from the CDC code. RMTA0, CORE and TEKLIB are commonly used PDP8/E library routines. LINEAX is a newer version of the line axis routine previously used on the PDP8/E. Running JWPLOT is as any other Fortran program except that a data file is necessaryfor corrected JW.

```
J W P L O T --- VERSION: 1.00.0


CALIBRATION DATE IS 26-SEP-80, CHANGE VALUES? (Y/N)
Y

ENTER THE JW-LWC CALIBRATION (A,B,C)
-3.68,4\7.4E-4,0.0
3.68000E+00 7.40000E-04 0.00000E-01

ENTER THE PRESSURE CALIBRATION (A,B,C)
1132.0,-.0992,-.1649E-6
1.13200E+03-9.92000E-02-1.64900E-07

ENTER THE TAS CALIBRATION (A,B,C)
-50.0,.05,0.0
5.00000E+01 5.00000E-02 0.00000E-01

ENTER THE IAS CALIBRATION (A,B,C)
-637.94,.1866,-.9991E-5
6.37940E+02 1.86600E-01-9.99100E-06

ENTER THE TEMP CALIBRATION (A,B,C)
-50.74,.0098,.2525E-7
5.07400E+01 9.80000E-03 2.52500E-08

RAW DATA OUTPUT? (T/F)
F

USE CALCULATED TAS (T/F)
F

INPUT THE START AND STOP TIMES (HH MM SS HH MM SS)
00 00 00 99 99 99

DEFAULT VALUES FOR HT(KM) ARE  0.0, 10.0
DO YOU WISH TO CHANGE THE LIMITS? (Y/N)
Y

ENTER THE NEW LIMITS (MIN, MAX)
0.0,5.0

DEFAULT LIMITS FOR JW-LWC ARE -0.3,  1.5
DO YOU WISH TO CHANGE THE LIMITS? (Y/N)
N

ENTER FLT ID (EXX-XX)
E80-04

ENTER FLT DATE (DD-MMM-YY)
?8-JAN-80
```

Figure 4.7: JWPLOT dialogue

4.3.2.3 JWPLOT.FT (cont'd)

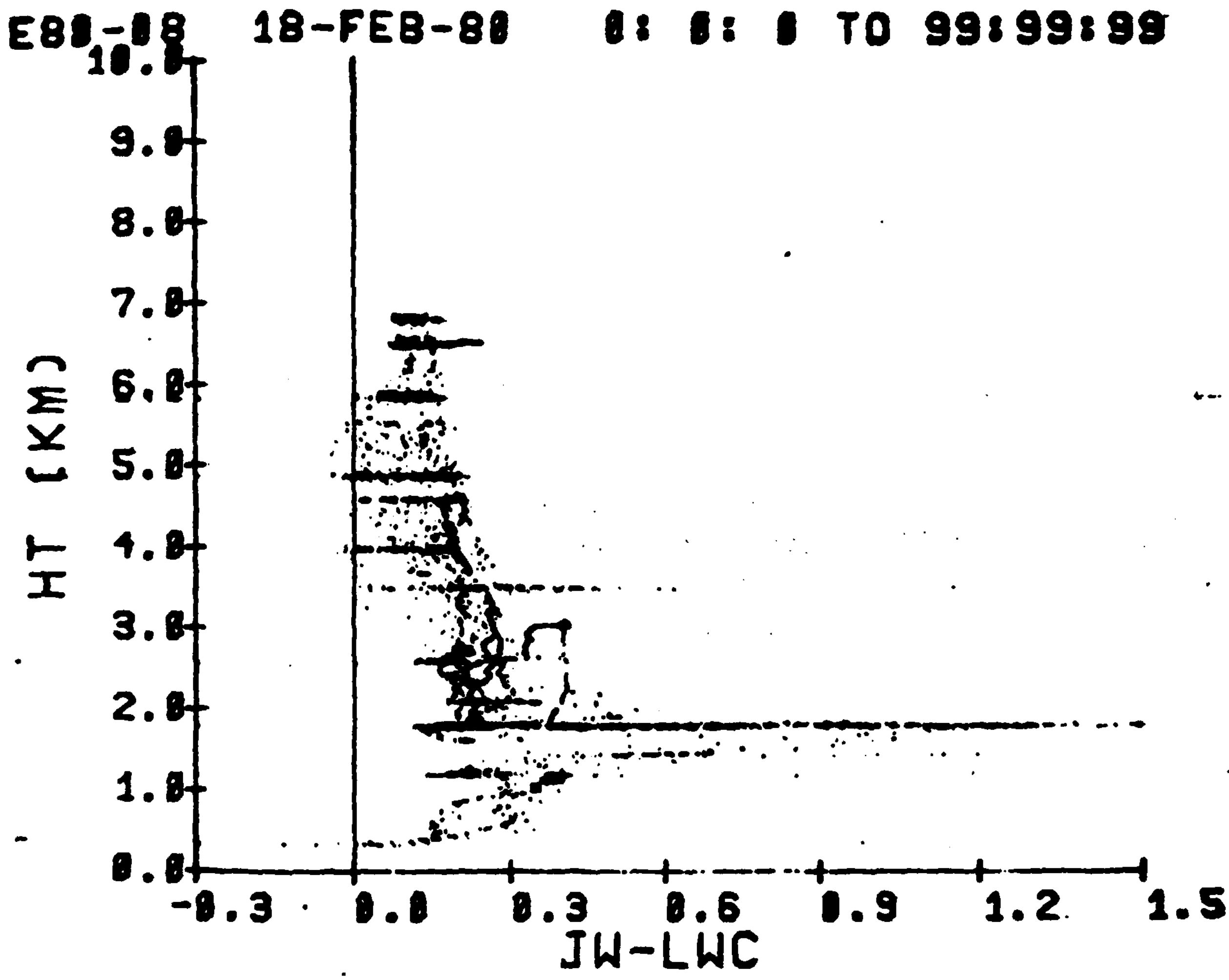


Figure 4.8A: JWPLOT sample output - uncorrected

4.3.2.3 JWPLOT.FT (cont'd)

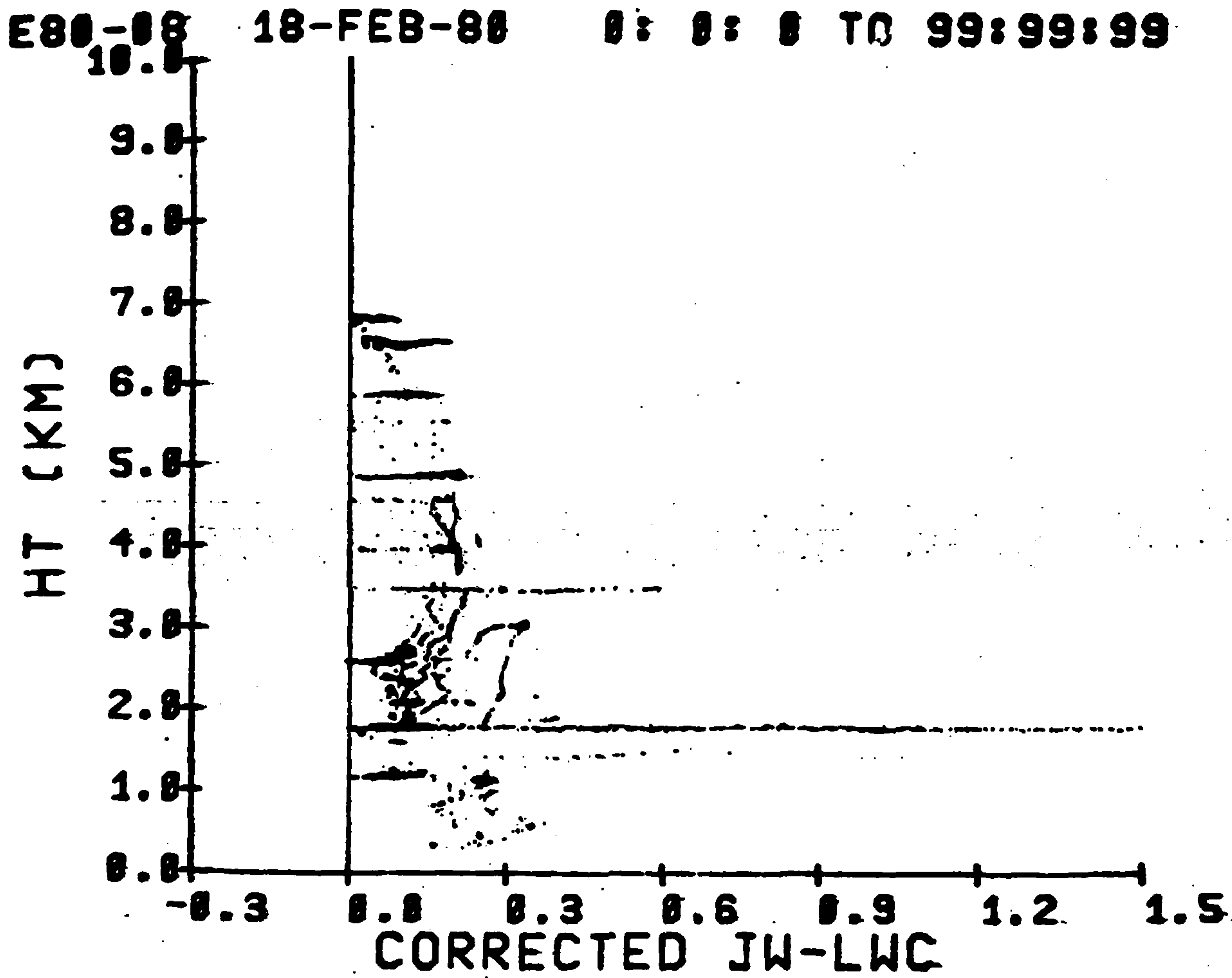


Figure 4.8B: JWPLOT sample output - corrected

4.3.2.3.1 CONTIM.FT

CONTIM is used by JWPLOT and will convert total seconds to "HH:MM:SS".

```
CALL CONTIM (SECS,TIME)
```

where:

SECS are total seconds
TIME is a two element array which will contain "HH:MM:SS"

NOTE: CONTIM will insert leading zeros for time parameters less than ten. i.e. 12:03:00

4.3.2.3.2 INPUT.FT.

INPUT is another JWPLOT subroutine which will accept from the user:

(1) start and stop times (HH MM SS HH MM SS)
(2) new height (km) limits
(3) new JW-LWC limits
(4) flight ID
(5) flight date

This information is returned to JWPLOT through common memory.

4.3.2.3.3 DISPL.FT

DISPL is used in JWPLOT to draw the plotting area of the JW graph. Flight ID, flight data, start and stop times are draw at the top; x and y axis are drawn and labelled. Whether the plot is corrected or uncorrected data is indicated at the bottom.

4.3.2.3.4 JWCORR.FT

JWCORR is used in JWPLOT to perform the JW-LWC correction. By building a table of intercept points using the Tektronix cross-hairs (identifying true zero values), JWCORR can subtract or add the proper offset to align the JW-LWC data points to zero.

4.3.2.3.5 SCALE.FT

SCALE is used to program JWPLOT to scale JW/HT data points to the plotting area and to ensure that no points fall beyond x and y limits. If so, the points are set to extreme x and y values and plotting occurs on the graph boundaries.

4.3.2.3.6 READT.FT

READT was developed for JWPLOT to return one second data from a PMS 1D flight tape. READT uses the RMTA0 subroutine which processes four second tape data; however for each call to READT, a pointer (KNBASE) to the current second's data is incremented to the next second. After four calls (four seconds of data), READT reads another tape record

4.3.2.3.6 READT.FT (cont'd)

and resets KNBASE to second #1. Errors are detected by READT and generate an error message on the DECwriter terminal:

"TAPE ERROX X"

Where X is the error (1-7)

Error codes are then returned to JWPLOT for further processing. (i.e. END OF TAPE CONDITION).

4.3.2.3.7 LINEAX.FT

LINEAX is a Fortran subroutine which will draw and label an x or y axis on the Tektronix CRT. It replaces an older version also called LINEAX. The major differences being: (1) numbers plotted on the y axis are at 0° angles as is the x axis, and (2) axis max and min limits are scaled down automatically by LINEAX to ensure a maximum field width of 4 characters for each tic mark numeric-label.

4.3.3 Fortran subroutines

There is a set of Fortran (also written in RALF) subroutines used on the PDP8/E for processing aircraft data.

(1) RMTA0: was written in RALF assembler to convert PMS 1D or TU-10 flight tapes to Fortran format

(2) CORE: was received through the "PDP-8 Software News" Fall 1980 magazine. CORE enables Fortran IV to execute the ENCODE and DECODE functions not possible before in PDP8/E Fortran IV

(3) SCANT: was developed to eliminate the drudgery of processsing tape errors when using RMTA0. SCANT also very quickly searches tapes for start times.

4.3.3.1 Subroutine RMTA0

RMTA0 is a RALF coded subroutine used by Fortran programs to read PMS 1D and TU-10 flight tapes. Since its inception, many revisions have been developed to make RMTA0 an extremely versatile addition to the Fortran library. RMTA0 features include:

1) processes PMS or flight tapes
2) seven diagnostic error codes
3) five tape functions (expandable to eight)
4) TU-10 tapes include LAT/LON and event word data
5) economical memory resources

RMTA0 requires six arguments per call:

```
CALL RMTA0 (A1,A2,A3,A4,A5,A6)
```

where:

A1 = 276 element array tape buffer

1-64	Second	1	
65-128	"	2	Knollenberg buffer see appendix 8
129-192	"	3	
193-256	"	4	
257-258	"	1	
259-260	"	2	Latitude/Longitude (in radians)
261-262	"	3	
263-264	"	4	
265	"	1	
266	"	2	event word data (1 thru 5)*
267	"	3	
268	"	4	

4.3.3.1 Subroutine RMTA0 (cont'd)

269-270	Second 1	
271-272	" 2	SIGN & ID data word for LAT/LON
273-274	" 3	
275-276	" 4	

* event word codes

1 = RAIN
2 = WET SNOW
3 = SMALL SNOW
4 = LARGE SNOW
5 = BULLET ROSETTES

A2 = tape format

0 = Kennedy tape
1 = TU-10 tape
INS data in RAW format

2 = TU-10 tape
INS in FPP format

3 = TU-10 tape
INS in semi-FPP format

A3 = A-D buffer tape

0 = OLD (BEFORE APRIL 1980)

1 = NEW (AFTER APRIL 1980)

A4 = tape error code

CODE	MEANING
0	NO ERROR
1	PARITY
2	END OF FILE
3	INCORRECT RECORD LENGTH
4	BEGINNING OF TAPE
5	DRIVE OFF LINE
6	END OF TAPE * (AT EOT, RMTA0 AUTOMATICALLY PERFORMS A REWIND
7	BLANK TAPE READ

4.3.3.1 Subroutine RMTA0 (cont'd)

A5 = - number of second to process for READ (FUNCTION 0) OR
+ number of records to space forward or backward (FUNCTIONS 3 and 4)

A6 = tape drive function

CODE	MEANING
0	READ A RECORD AND CONVERT TO FPP
1	REWIND DRIVE, TURN OFF LINE
2	REWIND DRIVE
3	FORWARD SPACE
4	BACKSPACE
5	
6	UNUSED, PRODUCES 'OFFLINE' #1
7	

The source file of RMTA0 is on tape #14 and is called RMTA0.RA.

4.3.3.2 Subroutine CORE

The CORE subroutine, received from "PDP-8 Software News" Fall 1980 magazine, is a RALF coded program which will create a memory I/O buffer accessible via Fortran READ/WRITE commands. CORE requires only one call to define the I/O unit number. More than one call will produce unpredictable results.

```
CALL CORE (u)
```

Where: u is the I/O unit to assign the memory buffer (not previously used in system configuration - our system uses Unit 5)

A write to the memory device is like printing on the terminal. A read will transfer the buffer to Fortran as through the characters were typed on the keyboard.

ENCODE - Simulated feature

A number can be written to the memory device using a numeric format (I,F,D) then read back using alphanumeric format (A).

example:

```
          NUMBER=12.3
          WRITE (5,10) NUMBER
   10     FORMAT (F6.2)
          READ (5,20) ALPHA
   20     FORMAT (A6)
```

At this point, Alpha = "12.3"

The ENCODE function is particularly useful as demonstrated by the NUMBER subroutine (on the following page).

4.3.3.2 Subroutine CORE (cont'd)

DECODE - Simulated feature

Virtually identical to encode, decode will convert an alphanumeric string to number format.

```
      ALPHA=6H 14.67
      WRITE (5,10) ALPHA
10    FORMAT (a6)
      READ (5,20) NUMBER
20    FORMAT (F6.2)
```

NUMBER is now set to 14.67

4.3.3.3 Subroutine SCANT

Every job run on the PDP8/E computer which processes aircraft data tapes requires TU-10 drive control. Every job must also process tape error messages, should an error occur during execution. Most jobs handle data in a time frame; that is, within a start and stop time. For these reasons DPSI has developed a RALF subroutine (SCANT) to handle magtape overhead control.

Subroutine SCANT interfaces the user Fortran IV program with the RMTA0 (read magtape 0) subroutine. SCANT features include:

1. reset, read and scan functions
2. common memory communication block
3. stop time detection and start time not located
4. full tape error diagnostics in simple English
5. aircraft clock rollover algorithm

All communication variables and parameters are passed through common 'A'. This common block contains the following:

KNBUF	Knollenberg tape buffer
KNBASE	PTR to current second in KNBUF
FORMAT	tape format (PMS/TU-10)
ATOD	ATOD buffer type
ERROR	RMTA0 error code
SECCNT	number of seconds to process (1,2,3,4)
CURSEC	current second
RECORD	current tape record

4.3.3.3 Subroutine SCANT (cont'd)

STARTT	search start time
STOPT	search stop time
FIRSTT	first time on tape
FUNCT	SCANT function
TERROR	SCANT error code

Internal time is always maintained in total seconds (H*3600 + M*60 + S) as in variables CURSEC, STARTT, STOPT, FIRSTT. Whenever time is printed, as in error messages, it is converted back to a normal format (HH:MM:SS). When a rollover condition occurs , 24 hours (86400 seconds) is added to CURSEC, therefore if a start time greater than 23:59:59 is specified, it too should include a 24 hour roll-over, i.e. 25:05:00.

The three functions RESET, READ and SCAN of subroutine SCANT are selected through an arithmetic variable, FUNCT:

FUNCT.LT.0 — RESET
rewind tape drive and read record one. FIRSTT is set to the first time on the tape.

FUNCT.EQ.0 — READ
one second of tape data is read. *

FUNCT.GT.0 — SCAN
the time in STARTT is searched for in whatever direction necessary.

* One tape record contains four seconds of data. When a record is phyiscally read, KNBASE is set to second 1, (=0); when a READ is processed, KNBASE is incremented to second 2 (=64), second 3 (=128), second 4 (=192), second 5; next record is read, and KNBASE is set to 0.

4.3.3.3 Subroutine SCANT (cont'd)

If SCANT intercepts a search error, it reports it through another arithmetic variable, TERROR.

TERROR.LT.0 the stop time (in STOPT) has been exceeded by the last read. *

TERROR.EQ.0 no error

TERROR.GT.0 the start time (in STARTT) has not been located. It could be either before FIRSTT or after the EOF, EOT or BTR.

* A stop time will result if a) the stop time has been passed, b) or if an EOF, EOT or BTR has been detected. ERROR will contain the actual situation. See section 4.3.3.1 for RMTA0 error codes.

After each call to subroutine RMTA0, SCANT interrogates the tape error word, a non-zero value calls the error message processor. These are seven possible errors:

1) PARITY
   displays error message
   "HH:MM:SS PARITY ERROR ON RECORD: XXXX"
   the next record is read.

2) END OF FILE (EOF)
   displays error message
   "HH:MM:SS END OF FILE AT RECORD: XXXX"
   if SCANT was currently searching for a start time, TERROR=1.
   If the EOF occurred during a read, TERROR=-1.

4.3.3.3 Subroutine SCANT (cont'd)

3) INCORRECT RECORD LENGTH (IRC)
displays error message
"HH:MM:SS INCORRECT RECORD LENGTH ON RECORD: XXXX"
the next record is read

4) BEGINNING OF TAPE (BOT)
no error message, used for search function. If BOT is hit twice in a row during a search, TERROR=1.

5) OFF-LINE
"*** TU-10 OFF-LINE... FIX AND PRESS RETURN!"
Correct the tape drive problem and press the keyboard return key.

6) END OF TAPE (EOT)
displays error message
"physical end of tape"
the end of tape marker has been sensed. If SCANT was currently searching, TERROR=1. If the EOT occurred during a read, TERROR=-1.

7) BLANK TAPE READ (BTR)
displays error message
"BLANK TAPE READ (HH:MM:SS)"
The last read took too long, and therefore no data is on the tape. If SCANT was currently searching TERROR=1. If the BTR occurred during a read, TERROR=-1.

4.4 Tektronix plotting package

When the Cloud Physics Branch received the Fortran IV system, processing of aircraft data was virtually unlimited. Almost anything done on the CDC could be done on the PDP8/E except plotting.

Fortran IV will support a Calcomp plotter which was in division property, but there was no interface. Cloud Physics also had a Tektronix graphic terminal but Fortran IV did not support one.

DECUS (Digital Equipment Corporation Users Society) catalogue contained a Fortran IV plotting package for the 4010 terminal at only reproduction costs ($40). Cloud Physics purchase this software and it has been incorporated into the system library.

4.4.1 TKPLOT.RA

TKPLOT is a DECUS plotting package designed for PDP8/E Fortran IV and a Tektronix 4010 terminal. It is compatible with DEC Calcomp software and includes facilities to save plots in a data file and then retrieve them later or send to a Calcomp plotter. TKPLOT contains the following subroutines:

XYPLOT	moves the pen to x,y coordinates specified with pen up or down
PLOTS	plotting package initializer
FACTOR	reduces or increase plotting image scale
WHERE	returns current x,y coordinates
PLEXIT	terminate plotting session
PAGE	user plot annotation subroutine
SPAGE	produces a hard copy of the CRT image
SYMBOL	plots a string or special character at the coordinates specified

XYPLOT, PLOTS, FACTOR, WHERE, PLEXIT and SYMBOL have Fortran standard calls and are referenced in the "OS/8 Handbook" on page 8-128. PAGE and SPAGE were included to allow manual annotation of a completed plot. PAGE has no arguments. Simply execute:

```
CALL PAGE
```

The Tektronix terminal will respond by illuminating the cross-hairs and beep the bell. PAGE has nine functions:

4.4.1 TKPLOT.RA (cont'd)

M	move (without drawing)
D	draw a line
A	draw a line with an arrowhead
P	draw a point
L	enter horizontal lettering mode
V	enter verticle lettering mode
Q	quit annotation (no hard copy, no saved plot)
S	save display (hard copy, plot saved in data file)
C	continue (no hard copy, plot saved in data file)

More information on TKPLOT may be found in the TKPLOT reference manual.

SPAGE is the same as calling PAGE and typing S for save plot. This feature allows a program to run by itself and produce hard copies.

4.4.2 Subroutine CROSS

Subroutine CROSS is a RALF coded routine which has been added to the Tektronix plotting package, TKPLOT. When called from Fortran IV, CROSS will illuminate the Tektronix cross-hairs. The user then positions them and signifies he/she is done by typing a character on the keyboard.

At this point, CROSS calculates the x,y coordinates of the cross-hair intersection (scaled to current limits) and returns them along with the coded character. Calling sequence is:

```
INTEGER CHAR
REAL X,Y
CALL CROSS (CHAR X,Y)
```

Where:

```
CHAR = character type
X    = x coordinate
Y    = y coordinate
```

On the following page is a list of keyboard characters and their corresponding codes.

4.4.2 Subroutine CROSS (cont'd)

CHARACTER TYPED	NUMBER RETURNED
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
A	17
B	18
C	19
D	20
E	21
F	22
G	23
H	24
I	25
J	26
K	27
L	28
M	29
N	30
O	31
P	32
Q	33
R	34
S	35
T	36
U	37
V	38
W	39
X	40
Y	41
Z	42

Table 4.9: CROSS character codes

4.4.3 Subroutine NUMBER

NUMBER is a Fortran subroutine which will plot the value of an integer or real variable on the Tektronix CRT. The plotting package received from DECUS did not contain this subroutine which left us unable to numerically annotate CRT plots. DECUS TKPLOT only included a symbol plotting routine, which is to say; 'alpha string plotting routine'. The original NUMBER routine developed by DPSI converted the number to alpha string, then called SYMBOL to plot the variable. With the addition of CORE (see section 4.3.3.2) to our PDP8/E library, NUMBER has been revised to use the CORE routine which increases the flexibility of plotting images. Call to NUMBER is:

```
CALL NUMBER (X,Y,H,N,A,F)
```

Where:

X,Y	x,y coordinates
H	height of digits
N	number to plot (integer/real)
A	angle
F	format (max field length =12)

Example:

```
                    X    Y   H    N       A     F
CALL NUMBER (1.0, 1.0.0.5, 3.1415, 0.0, 6H(F8.4))
```

Note: the format must appear as it would in a normal format statement; parentheses must be present and Hollorith format must be used.

4.4.3 Subroutine NUMBER (cont'd)

The DEC version of NUMBER Plots only integer or real formats. DPSI's version of the NUMBER subroutine will plot in any format (MAX 12 characters) i.e. F5.2, I7, E11.3, 1PE10.1, etc.

4.4.4 Subroutine LINEAX

LINEAX is a Fortran IV subroutine designed to draw and label an abcissa or ordinate axis on the Tektronix terminal. LINEAX was originally written by DPSI for use on the CDC 6600 computer, and then modified for use on the PDP8/E system.

LINEAX is extremely versatile and capable of drawing an axis of variable length and size. Features include:

1) label right or left of axis
2) selectable symbol and tic size
3) automatic exponential scaling of tic values

LINEAX requires ten arguments for each call. NOTE: the plotting package must be initialized by calling plots (CALL PLOTS), and the encode/decode feature must be assigned by calling CORE (CALL CORE(5)).
Call to LINEAX is:

```
CALL LINEAX (X,Y,LENGTH,ALPHA,NUMCHR,AXIS,START,STOP,
        CYCLE,SIZE)
```

Where:

X	x coordinate of left end of axis
Y	y coordinate of left end of axis
LENGTH	length of axis in inches
ALPHA	axis alphanumeric in ALPHA
NUMCHR	number of characters in ALPHA +NUMCHR = label left of axis -NUMCHR = label right of axis

4.4.4 Subroutine LINEAX (cont'd)

AXIS	axis orientation
	0 = x axis
	1 = y axis
START	starting axis value
STOP	ending axis value
CYCLE	number of divisions
SIZE	alphanumeric label size

The following figure is an example of LINEAX axis.

4.4.4 Subroutine LINEAX (cont'd)

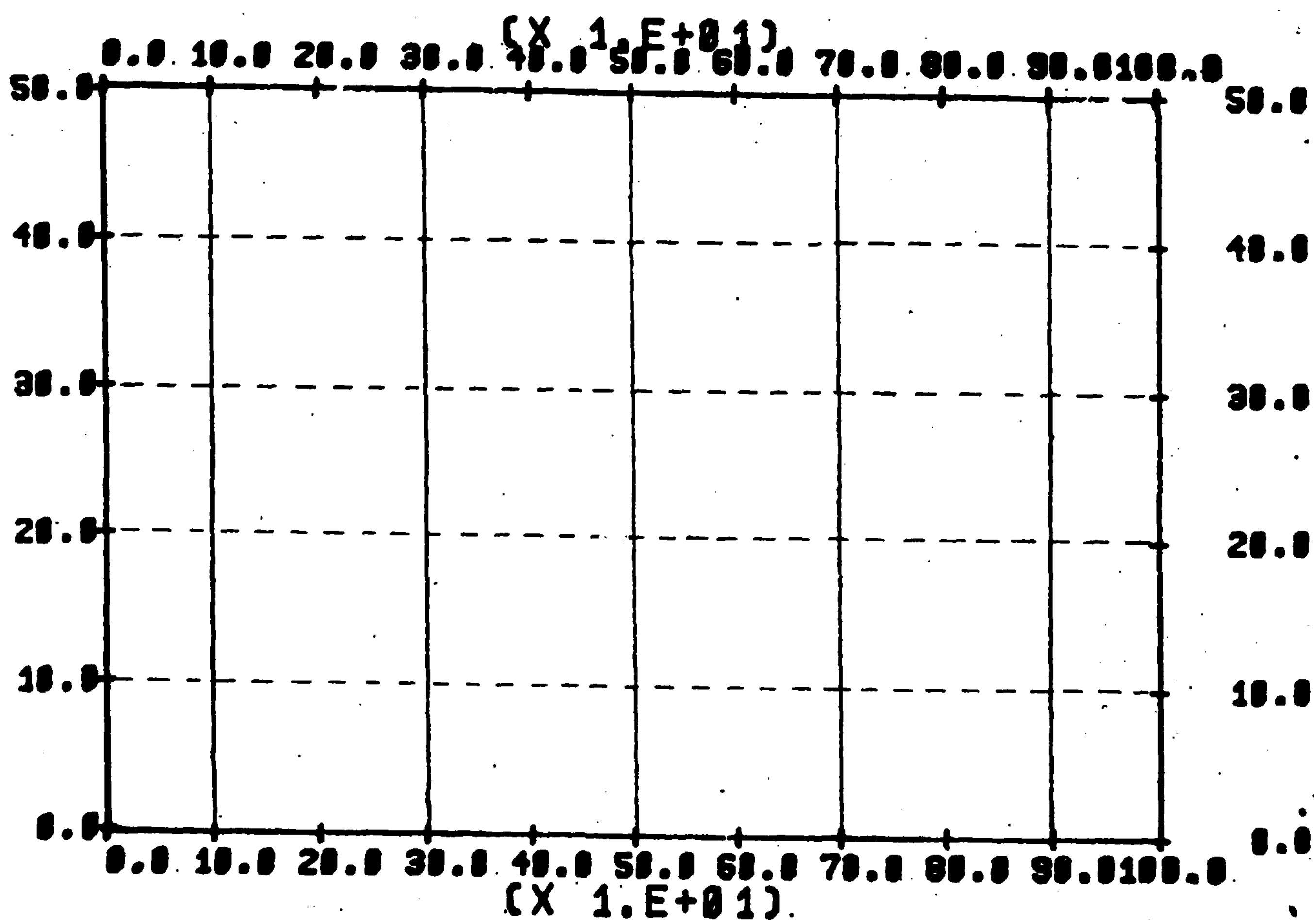
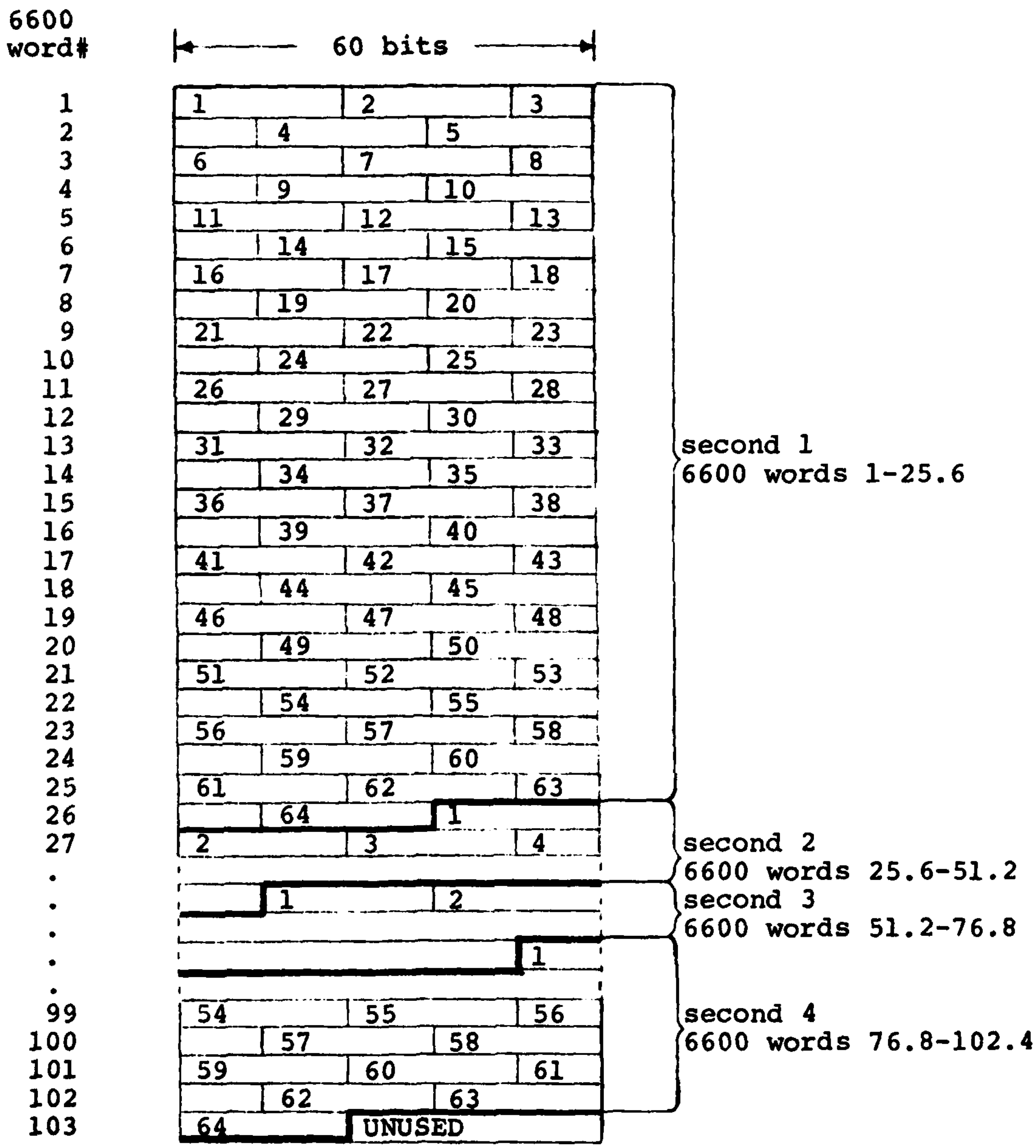


Figure 4.9: LINEAX sample plot

VCO CHANNEL	SYMBOL	DESCRIPTION	CALIBRATION INTERCEPT	SLOPE	3RD TERM	UNITS
1	IAS	Indicated Airspeed (a/c Pitot static)	- 695.67	.207	-.11516E-4	knots
2	TEMP	Total Temperature (Rosemount)	- 49.05	.0095	.32616E-7	°C
3	EWER		0	1	0	counts
4	TWCI	TEMP2 (fluid & water mix in measuring sensor)	0	1	0	counts
5	DEWP/FROS	Dewpoint (Cambridge 1011)	- 50.02	.0104	-.43953E-7	°C
6	LWC-JW	Liquid Water Content (Johnson Williams)	- 3.3	6.37E-4	0.0	gm/M^3
7	MHEAD	Magnetic Heading (a/c Compass)	180.0	- .036	0.00	°N
8	K-PRES	Air Pressure (Kistler)	+1135.76	- .1005	.50014E-7	mb
9	TAS	True Airspeed	- 50.0	+0.05	0.0	m/sec
10	ICING RATE		0.00	+1.0	0.0	counts
11	TWCI	CTR1 (reference frequency)	0	1	0	counts
12	TWCI	TEMP1 (temp of carrier fluid in ref. sensor)	0	1	0	counts
13	TWCI	CTR2 (measured frequency)	0	1	0	counts

Appendix 1: VCO's recorded on C-130 PMS-1D system

Record length:	1024 characters
Character length:	4 bit BCD + 2 leading bits
Buffer size:	103 60 bit words or
	256 24 bit words
Time:	4 seconds/record
	64 24 bit words/second
Parity:	odd
Density:	556 bits per inch



For a complete description of the 64 word block refer to appendix 8.

Appendix 2: Kennedy tape record format

CODE	PARTICLE TYPE
1	RAIN
3	WET SNOW
5	LARGE SNOW
7	SMALL SNOW
9	BULLET-ROSETTES
11	COLUMNS (4:1 ASPECT RATIO)
13	NEEDLES (7.5:1 ASPECT RATIO)
15	PLATE FAMILY
17	AGGREGATE PLATES & DENDRITE
19	DENDRITE FAMILY
21	GRAUPEL
23	RIMED DENDRITES

NOTE: EVEN TYPE CODES ARE USED INTERNALLY IN THE PROGRAM

Appendix 3: 1D Particle Type Codes

TYPE NUMBER	**HTOX TABLE** NAME	EQUATION NUMBER	ADJUSTED CLASS M	B	BREAKPOINT (N)
1	RAIN	1	.990	.180	
3	WET SNOW	1	.990	.180	N LE 2.
		2	1 150	.180	
5	LARGE SNOW	1	1.150	.180	
7	SMALL SNOW	1	1.150	.180	
9	BULLET-ROSETTES	1	1.018	.318	
11	COLUMNS	1	1.302	.761	
13	NEEDLES	1	200	3.040	N LE 1.
		2	1.280	1.080	
15	PLATE FAMILY	1	.938	.549	N LE 3.
		2	1.076	.019	
17	AGGREGATE P + D	1	.940	.550	N LE 3.
		2	1 200	-.440	
19	DENDRITE FAMILY	1	1.030	.716	
21	GRAUPEL	1	1.150	.180	
23	RIMED DENDRITE	1	1.150	.180	

Appendix 4A: Particle Number Adjustment Coefficients (HTOX TABLE)

TYPE NUMBER	**XTOD TABLE** NAME	EQUATION NUMBER	EQ MELTED DIAMETER CO	EX	BREAKPT (CRSIZ)
1	RAIN	1	1.000E+00	1.000	
3	WET SNOW	1	1.000E+00	1.000	C LE 1.000 MM
		2	1.000E+00	.653	
5	LARGE SNOW	1	4.000E-01	.782	
7	SMALL SNOW	1	4.600E-01	.782	C LE .500 MM
		2	3.700E-01	.670	
9	BULLET-ROSETTES	1	2.560E-01	.667	C LE .200 MM
		2	4.380E-01	1.000	
11	COLUMNS	1	4.380E-01	1.000	
13	NEEDLES	1	2.560E-01	.670	
15	PLATE FAMILY	1	3.400E-01	.783	C LE 1.000 MM
		2	3.400E-01	.685	
17	AGGREGATE P + D	1	3.400E-01	.783	C LE 1.000 MM
		2	3.400E-01	.685	
19	DENDRITE FAMILY	1	3.400E-01	.780	
21	GRAUPEL	1	5.000E-01	.910	C LE .410 MM
		2	4.300E-01	.680	C LE 1.350 MM
		3	4.600E-01	.900	
23	RIMED DENDRITE	1	4.600E-01	.900	

Appendix 4B: Equivalent Melted Diameter Coefficients (XTOD TABLE)

WORD	CONTENTS
1	TIME @HH:MM:SS@
2	CHANNEL 16 COUNTS (INTEGER)
3	LARGEST PARTICLE SIZE (INTEGER-MU UNITS)
4	PARTICLE TYPE [(SCATTER*100+CLOUD)*100 +PRECIP]
5	AVERAGING INTERVAL (INTEGER SECONDS)
6	OUTPUT OPTION (0=ABRES, 1=AFWL)
7	INTERPOLATION SWITCH (o=OFF, 1=ON)
8	FLIGHT ID FLT E78-01
9	FLIGHT DATE @DD@MON@YR
10-54	NORMALIZED CHANNEL NUMBER DENSITIES *
55-67	CALIBRATED VCO VALUES
68-71	PROBE LWC TOTALS **
72-75	PROBE Z TOTALS **
76-79	PROBE D0 VALUES **
80-83	PROBE K VALUES **
84	FORM FACTOR
85	NT
86-130	CHANNEL CENTER DIAMETERS ***
131-175	CHANNEL BARWIDTH'S IN MM ***
176-220	CHANNEL LIQUID WATER CONTENTS *
221	POTENTIAL TEMPERATURE
222	DEWPOINT
223	SATURATED VAPOR
224	VAPOR
225	RELATIVE HUMIDITY

* ARRANGED IN ORDER (15,3), 15 CHANNELS OF SCATTER, CLOUD THEN PRECIP

** IN THE ORDER OF SCATTER, CLOUD, PRECIP THEN TOTAL PROBE

*** ARRANGED IN ORDER (3,15), CHANNEL 1 OF EACH PROBE FOLLOWED BY CHANNEL 2 OF EACH PROBE, ETC...

@ SPACE

Appendix 5: KNOLL1D (TAPE2) Output Format

WORD	KNPLT1D AXIS CODE	NAME
55	1	PRESSURE
56	2	EWER
57	3	HEIGHT
58	4	TEMPERATURE
59	5	DEWPOINT
60	6	LWC-JW
61	7	LWC-IR
62	8	LWC-TWCI
63	9	INDICATED AIRSPEED
64	10	MAG HEADING
65	11	CALCULATED AIRSPEED
66	12	TRUE AIRSPEED
67	13	TWCI-1
68	14	LWC SCATTER
69	15	LWC CLOUD
70	16	LWC PRECIP
71	17	LWC TOTAL
72	18	Z SCATTER
73	19	Z CLOUD
74	20	Z PRECIP
75	21	Z TOTAL

Appendix 6: KNOLL1D (TAPE2) VCO Placement

ending digit of second	scatter probe status	#	cloud probe status	#	precip probe status	#
0	+15v. supply voltage	1	+15v. supply voltage	2	+15v. supply voltage	3
1	probe temp	4	mirror temp	5	mirror temp	6
2	size range selected	7	element 1 voltage	8	element 1 voltage	9
3	laser reference voltage	10	element 24 voltage	11	element 24 voltage	12
4	-15v. supply voltage	13	-15v. supply voltage	14	-15v. supply voltage	15
5	electronics temp	16	+5v. supply temp	17	+5v. supply temp	18
6	+5v. supply voltage	19	+5v. supply voltage	20	+5v. supply voltage	21
7	+5v. supply temp	22	electronics temp	23	electronics temp	24
8	+15v. supply voltage	25	+15v. supply voltage	26	+15v. supply voltage	27
9	probe temp	28	mirror temp	29	mirror temp	30

Appendix 7A: PMS 1D status word allocation

Status word #	Parameter
1	Percent overload
2	diode #1 reference voltage
3	diode #32 reference voltage
4	-15v. supply voltage
5	-12v. supply voltage
6	+5v. supply 'A' voltage
7	+5v. supply 'B' voltage
8	+15v. supply voltage
9	mirror temperature

Appendix 7B: PMS 2D status word allocation

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	elapsed time	IAS	TEMP	EWER	TWCI TEMP2	DEWP	LWC-JW	HEAD-ING	PRES-SURE	TAS	ICING RATE	TWCI CTR-1	TWCI TEMP1	TWCI CTR-2	min sec	hrs CH 16 counts
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
scatter	status *	ch 1	ch 2	ch 3	ch 4	ch 5	ch 6	ch 7	ch 8	ch 9	ch 10	ch 11	ch 12	ch 13	ch 14	ch 15
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
cloud	status *	ch 1	ch 2	ch 3	ch 4	ch 5	ch 6	ch 7	ch 8	ch 9	ch 10	ch 11	ch 12	ch 13	ch 14	ch 15
	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
precip	status *	ch 1	ch 2	ch 3	ch 4	ch 5	ch 6	ch 7	ch 8	ch 9	ch 10	ch 11	ch 12	ch 13	ch 14	ch 15

Appendix 8: PMS/VCO Output Block

TAPE1 (SPANDAR)
PARITY: EVEN
DENSITY: 800 BPI (7 TRACK)
RECORD: VARIABLE LENGTH
TIME: 1 SECOND PER DATA RECORD

The SPANDAR input tape consists of multiple sets of:
1 header record followed by many data records

HEADER RECORD (28 bytes)

BYTES	TYPE	DESCRIPTION
6	8 bit EBCDIC	A/C type (6 char)
2	fixed binary	Run ID Number (pass)
2	"	Day of Scan (DOY)
2	"	Year of Scan (2 digits)
2	"	Scan Number
2	"	Time of Scan (hours)
2	"	Time of Scan (minutes
2	"	Number of data records
4	floating point	Time of Scan (seconds)
4	"	Nominal Altitude (feet)

DATA RECORDS one per second (40 bytes)

2	fixed binary	Greenwich Time (hours)
2	"	Greenwich Time (minutes)
4	floating binary	Greenwich Time (seconds)
4	"	Average Reflectivity (dbz)
4	"	Elevation (degrees)
4	"	Azimuth (degrees)
4	"	Radar Slant Range (nm)
4	"	Ground Range (nm)
4	"	Ground Range (nm)
4	"	Altitude (feet)
4	"	Altitude (km)

Appendix 9: SPANDAR Input Tape Format

TAPE3

TYPE: SCOPE-NOS/BE STANDARD
RECORD: VARIABLE LENGTH
TIME: 1 SECOND PER DATA RECORD

HEADER RECORD LENGTH 2 WORDS

WORD 1 ZERO OR DAY OF YEAR
WORD 2 FOR SPANDAR TAPE

DATA RECORD LENGTH 7 WORDS (DISPLAY CODE)

SPANDAR output tape consists of multiple sets of header record followed by a variable number of data records

FORMAT	DESCRIPTION
2X	blank
I3	GMT (hours)
I3	GMT (minutes)
F7.3	GMT (seconds)
F9.0	radar slant range (meters)
F8.3	azimuth (degrees)
F7.3	elevation (dgrees)
F9.0	altitude (meters)
F7.1	reflectivity (dbz)
F6.0	counts (forced to zero)

Appendix 10: SPANDAR Output Tape Format

Data collected by the cloud and precip PMS-2D data acquisition devices are written to tape by a PERTEC recorder. The data collected by either device is double-buffered to minimize loss of data.

There are two kinds of records written to this tape, slow and fast.

Slow data records are 86 CDC 6600 words long and contain the real time clock value and VCO readings for each second. One slow record is written every ten seconds and thus contains ten seconds worth of data.

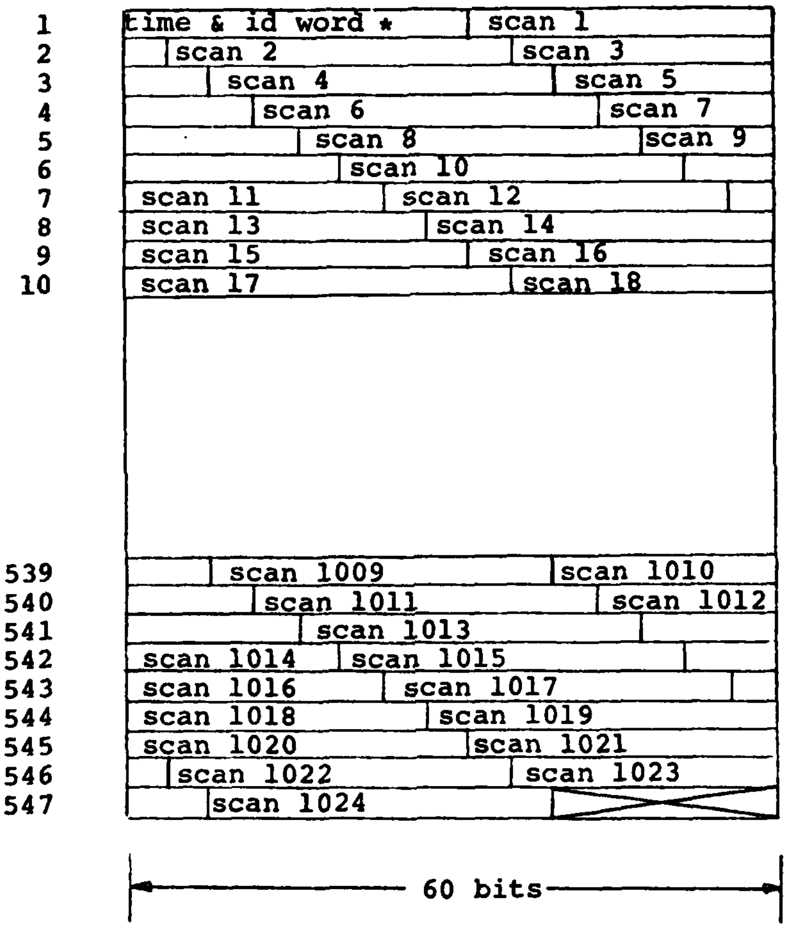
Fast data are the records produced by the PMS-2D buffers, and are 547 60 bit words in length. These records contain the results of 1024 scans of the 32 diodes. Each scan is a binary representation of each diodes state. If when scanned a diode was on, a zero is recorded; if off, a one is recorded. In order to minimize data written, all blank scans are counted and when the next particle is detected, the number of blank scans is written onto the tape. This counter is prefaced by a bit pattern of 10101010 to differentiate from a regular diode scan. The first scan has the elapsed second counter, overload status and a probe indicator. If one buffer is being written to tape and the other buffer for this probe is also filled, the probe is said to be overloaded.

Appendix 11: PMS-2D Particle Image Tape Description

RECORD LENGTH: 1025 32 bit scans
547 60 bit words

SCAN RATE: 1 every 250 nano-seconds maximum

6600 WORD#

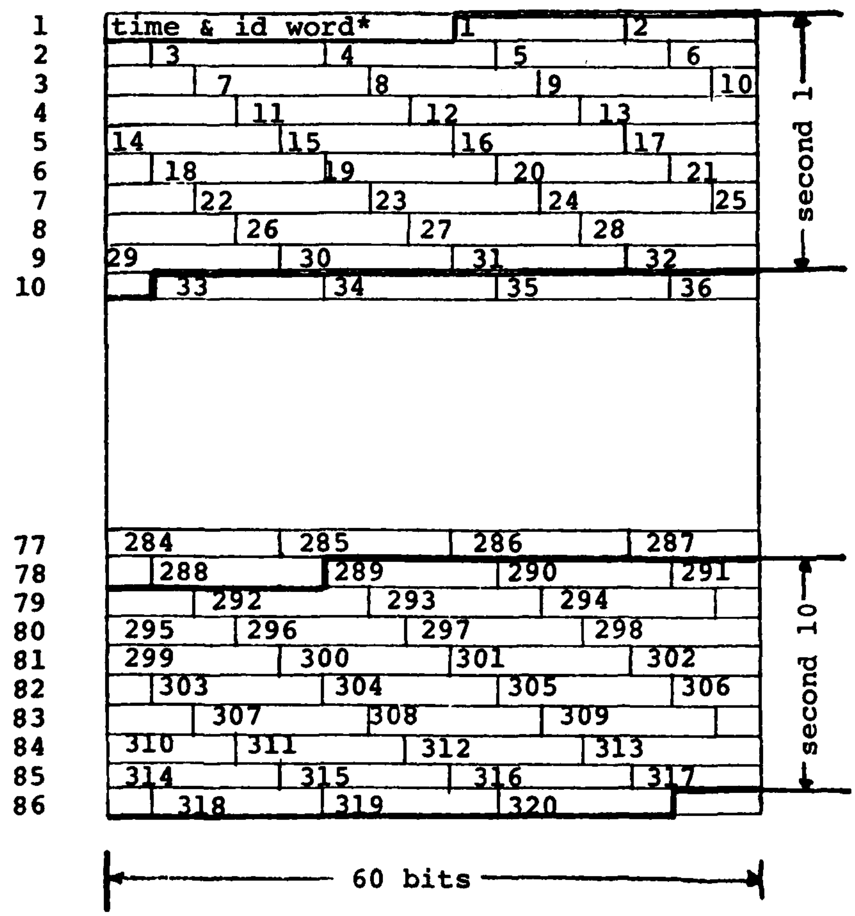


* see appendix 12C for time and id word description

Appendix 12A: MC-130E/Lear PMS-2D Fast-data Record Format

RECORD LENGTH: 322 16 bit words
86 60 bit words
RECORD TIMING: 1 every 10 seconds

6600 WORD#



* see appendix 12C for time and id word description

Appendix 12B: MC-130E/Lear PMS-2D Slow-data Record Format

TIME BYTES

byte #		
1	elapsed seconds x 1000	elapsed seconds x 100
2	elapsed seconds x 10	elapsed seconds x 1
3	elapsed seconds x 0.1	elapsed seconds x 0.01
4	elapsed seconds x 0.001	Id 4 Id 3 Id 2 Id 1

← 8 bits →

note: every "seconds" digit is 4 bit BCD

IDENTIFICATION BITS

<table>
<tr><th rowspan="2"></th><th colspan="2">FAST DATA</th><th rowspan="2">SLOW DATA</th></tr>
<tr><th>C130E</th><th>C130A</th></tr>
<tr><td>Id 4</td><td>data source</td><td rowspan="4">seconds x .0001</td><td rowspan="4">all one's</td></tr>
<tr><td>Id 3</td><td>data source</td></tr>
<tr><td>Id 2</td><td>overload</td></tr>
<tr><td>Id 1</td><td>overload</td></tr>
</table>

Id 4 = 1, record from cloud size probe
Id 3 = 1, record from precip size probe
Id 2 = 1, cloud size probe overload
Id 1 = 1, precip size probe overload

note: Id 4 and Id 3 may not be one in the same record

Appendix 12C: MC-130E/Lear Time & ID Word Description

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sec.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	unused sec·10k	elapsed seconds	32 bits parallel	digital input	VCO channels 1	2	3	4	5	6	7	8	9	10	11	12
2	cloud status#1	precip status#1	cloud total 2D	precip total 2D	1	2	3	4	5	6	7	8	9	10	11	12
3	cloud status#2	precip status#2	#1 slow analog	#9 slow analog	1	2	3	4	5	6	7	8	9	10	11	12
4	cloud status#3	precip status#3	#2 slow analog	#10 slow analog	1	2	3	4	5	6	7	8	9	10	11	12
5	cloud status#4	precip status#4	#3 slow analog	#11 slow analog	1	2	3	4	5	6	7	8	9	10	11	12
6	cloud status#5	precip status#5	#4 slow analog	#12 slow analog	1	2	3	4	5	6	7	8	9	10	11	12
7	cloud status#6	precip status#6	#5 slow analog	#13 slow analog	1	2	3	4	5	6	7	8	9	10	11	12
8	cloud status#7	precip status#7	#6 slow analog	#14 slow analog	1	2	3	4	5	6	7	8	9	10	11	12
9	cloud status#8	precip status#8	#7 slow analog	#15 slow analog	1	2	3	4	5	6	7	8	9	10	11	12
10	cloud status#9	precip status#9	#8 slow analog	#16 slow analog	1	2	3	4	5	6	7	8	9	10	11	12

Appendix 12D: MC-130E PMS-2D Slow-data Record Word Allocation

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	word#
2D clock percent	1D cloud probe counts by channel															1-32
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
precip total	1D precip probe counts by channel															33-64
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
REPEAT SECOND 1																65-96
REPEAT SECOND 2																97-128
REPEAT SECOND 1																129-160
REPEAT SECOND 2																161-192
REPEAT SECOND 1																193-224
REPEAT SECOND 2																225-256
REPEAT SECOND 1																257-298
REPEAT SECOND 2																299-320

Appendix 12D: MC-130E PMS-2D Slow-data Record Word Allocation

RECORD FORMAT: SCOPE-NOS/BE
RECORD LENGTH: VARIABLE MINIMUM 12 WORDS, MAXIMUM 512
RECORD TYPE: BINARY

WORD	DESCRIPTION	
1	TIME OF RECORD IN FORM HH:MM:SS.F	(DISPLAY CODE)
2	SLOW RECORD AND FAST RECORD NUMBER IN FORM WORD 2 = SLOW*10000 + FAST	(BINARY)
3	SAMPLE TIME IN MS	(BINARY)
4	CLOCK SAMPLING RATE-PERCENTAGE	(BINARY)
5	PROBE	(BINARY)
6	OVERLOAD INDICATOR	(BINARY)
7	KISTLER AND BACKUP PRESSURE IN FORM WORD 7 = KIST*10000 + PRESS	(BINARY-VCO COUNTS)
8	PRESSURE GRADIENT VCO COUNTS	(BINARY-VCO COUNTS)
9	TEMPERATURE VCO COUNTS	(")
10	DEWPOINT VCO COUNTS	(")
11	TRUE AIRSPEED	(")
12	JW-LWC VCO COUNTS	(")
13	AREA IN SQUARE DIODES-NEGATIVE IF EDGE REJECTION	(BINARY)
14	PERIMETER IN DIODES	(")
15	HORIZONTAL FERET PROJECTION IN DIODES	(BINARY)
16	VERTICAL FERET PROJECTION IN DIODES	(")
17	HORIZONTAL PROJECTIONS IN DIODES	(")
18	VERTICAL PROJECTIONS IN DIODES	(")
19	VERTICAL EDGE (IN DIODES)	(")
20	MAXIMUM LENGTH IN DIODES	(")
*21	THETA ANGLE OF PARTICLE ORIENTATION	(")
*22	VOLUME IN CUBIC DIODES	(")
.		
.		
.		
512	VOLUME IN CUBIC DIODES	

* NOT USED WHEN LMAX APPROXIMATION MADE

Each record consists of the 12 word identification block and then up to 50 particle descriptions, each 10 words long. One fast input record to TWODEE can generate one or more of these records. The length of each output record is determined by the number of particles in each fast input record.

Appendix 12E: PMS-2D Particle Tape Format

WORD	CONTENTS
1	TIME OF RECORD (IN SECONDS)
2	FLIGHT IDENTIFICATION
3	FLIGHT DATE
4	LATITUDE (NOT USED AS YET)
5	LONGITUDE (NOT USED AS YET)
6	TEMPERATURE (TRUE IN DEGREES CENTIGRADE)
7	TEMPERATURE (TOTAL IN DEGREES CENTIGRADE)
8	DEWPOINT (IN DEGREES CENTIGRADE)
9	JW-LWC (UNADJUSTED GM/M**3)
10	PRESSURE (MILLIBARS)
11	TRUE AIRSPEED (M/SEC)
12	ICING COUNT
13	CODE 1=STANDBY RECORD, 2=TRIGGER RECORD, 3=SENSING RECORD
14	ALTITUDE (METERS)
15-29	CHANNEL COUNTS FOR CHANNELS 1-15 OF THE SCATTER PROBE
30-44	CHANNEL COUNTS FOR CHANNELS 1-15 FOR THE CLOUD PROBE
45-59	CHANNEL COUNTS FOR CHANNELS 1-15 OF THE PRECIP PROBE

ALL VALUES ARE IN FLOATING POINT FORMAT. RECORD IS 59 WORDS LONG WRITTEN BY A FORTAN BINARY WRITE STATEMENT (WRITE(UNIT)LIST)

Appendix 13: ICEEX Output Tape Format

Data collection by ice detector can be characterized by three distinct modes of operation.

1) sensing mode
2) detecting mode, and
3) standby mode.

These modes occur in the sequence listed. The standby mode however, can be triggered manually at any time.

A. In the sensing mode the probe is signaling that ice is accumulating on it. The counts will range in the mode from 6250 to 9818. (The latter value being equal to 4.8 volts at which point the accumulation of ice triggers the detecting mode). If icing rates are very low it is possible that the probe will remain in the sensing mode, i.e., never accumulating enough ice to go into the detecting mode or the ice will evaporate and counts will decrease in value to approximately 6250.

In the detecting mode, an ice signal is generated and heating cycle is initiated. During this period random counts are generated. Typically values under 5000 are generated (see C) for a number of seconds. All these data (i.e., exceeding 9818 and less than 5000 counts) are to be disregarded as data, but to be used as the indicator of a change from the detecting to standby mode.

The standby mode follows the detecting mode and has a range of counts from 5350 to 5150. The most frequently observed values is 5250 counts. In this mode all ice

has been removed from the detector, and the DC current to the probe has been cutoff. Typically this mode lasts under 2 seconds.

The time needed for the ice detector to return from standby mode to the sensing mode depends on icing conditions, ambient temperature and airspeed. With moderate icing 7-10 seconds are typical. The return to the sensing mode occurs when counts equal 6250.

B. It is possible while in the sensing mode for apparently random counts to be generated; that is, 9818 counts has not been reached nor exceeded and apparently random signals, (similar to those occurring when the instrument is in the detecting mode) are observed. Following the occurrence of these random counts, the counts recorded return to values indicating the unit is still in the sensing mode.

C. Random counts are sudden large excursion in magnitude. Since these occur primarily in connection with the change from sensing to detecting mode and frequently occur with voltages exceeding 5V, causing a rollover in counts, (i.e., numbers > 9999 begin at 0001) it is useful to add 10000 counts to all values < 5000.

A to D Buffer (OLD: before April 80)

WORD	CONTENTS
1	
2	
3	
4	
5	
6	Event Word
7	Latitude
8	
9	
10	Longitude
11	
12	
13	
14	

Repeated 4 times per second

Appendix 15: TU-10 tape format

A to D Buffer (NEW: After April 80)

WORD	CONTENTS
1	Event Word
2	
3	Latitude
4	
5	
6	Longitude
7	
8	
9	
10	
.	TWCI data buffer
.	words 8-39
.	
.	
37	
38	
39	
40	
41	
42	
.	Reserved for expansion
.	words 40-56
.	
.	
54	
55	
56	

1 second Data

Appendix 15: TU-10 tape format (cont'd)

KNOLLENBERG BUFFER

WORD	1 Second Data (repeated 4 times per record)
225	elapsed seconds
226	IAS
227	TEMP
228	EWER
229	TWCI TEMP2
230	DEWP
231	JW/LWC
232	MAGH
233	AIR PRES. KISSLER
234	TAS
235	ICE DETECTOR
236	TWCI CTR1
237	TWCI TEMP1
238	TWCI CTR2
239	MINUTES/SECONDS
240	PRECIP#16/HOURS
	SCATTER PROBE
241	HOUSEKEEPING
242	CHANNEL #1
243	#2
244	#3
245	#4
246	#5
247	#6
248	#7
249	#8
250	#9
251	#10
252	#11
253	#12
254	#13
255	#14
256	#15

Appendix 15 TU-10 Tape Format (cont'd)

KNOLLENBERG BUFFER

WORD		
257	HOUSEKEEPING	CLOUD
258	CHANNEL #1	PROBE
259	#2	
260	#3	
261	#4	
262	#5	
263	#6	
264	#7	
265	#8	
266	#9	
267	#10	
268	#11	
269	#12	
270	#13	
271	#14	
272	#15	
		PRECIP
273	HOUSEKEEPING	
274	CHANNEL #1	PROBE
275	#2	
276	#3	
277	#4	
278	#5	
279	#6	
280	#7	
281	#8	
282	#9	
283	#10	
284	#11	
285	#12	
286	#13	
287	#14	
288	#15	

Appendix 15 TU-10 Tape Format (cont'd)

BUFFER WORD #	PARAMETER
1	DATE (YYMMDD)
2	TIME (HRMNSC)
3	CRYSTAL TYPE NUMERIC CODE (CLOUD PROBE)
4	CRYSTAL TYPE NUMERIC CODE (PRECIP PROBE)
5	TRUE AIRSPEED ($m\ s^{-1}$)
6	PRESSURE (mb)
7	ALTITUDE (km)
8	TEMPERATURE (°C)
9	DEWPOINT (°C)
10	WIND SPEED ($m\ s^{-1}$)
11	WIND DIRECTION (°)
12	LATITUDE (DEG AND FRACTIONS)
13	LONGITUDE (DEG AND FRACTIONS)
14	TRUE HEADING (°)
15	J-W LIQUID WATER ($g\ m^{-3}$)
16	TWCI ($g\ m^{-3}$)
17	UNUSED
18	UNUSED
19	MAX CRYSTAL SIZE IN MICRONS
20	ASP WATER CONTENT ($g\ m^{-3}$)
21	CPS WATER CONTENT ($g\ m^{-3}$)
22	PPS WATER CONTENT ($g\ m^{-3}$)
23	ASP REFLECTIVITY ($mm^6\ m^{-3}$)
24	CPS REFELCTIVITY ($mm^6\ m^{-3}$)
25	PPS REFLECTIVITY ($mm^6\ m^{-3}$)
26-70	RAW COUNTS FOR 15 CHANNELS OF 3 1D PROBES (SCATTER, CLOUD, PRECIP)
71-115	NON-NORMALIZED DENSITY FOR CHANNELS 1-45 (# m^{-3}) (SCATTER, CLOUD, PRECIP)
116-160	LIQUID WATER CONTENT FOR CHANNELS 1-45 ($g\ m^{-3}$) (SCATTER, CLOUD, PRECIP)
161-205	EQUIVALENT MELTED DIAMTERS FOR CHANNELS 1-45* (μm)

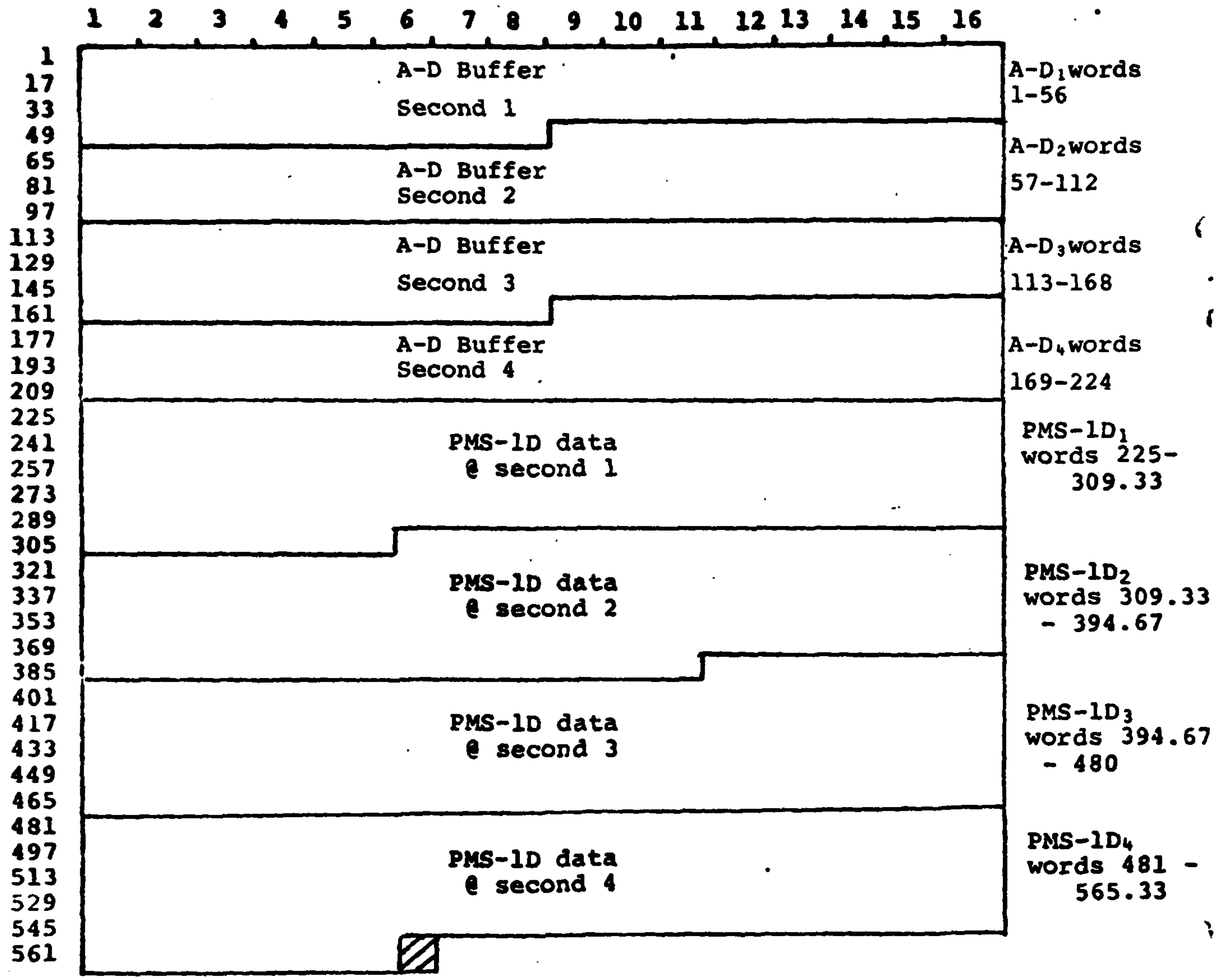
* EQUIVALENT MELTED DIAMTER IS GIVEN FOR CHANNLE 1 ALL THREE PROBES, THEN CHANNEL 2

Appendix 16: AEROMET 205 Word Processed Data Tape

RECORD LENGTH:	210 words (60 bit)
TIME:	1 record/second
PARITY:	odd
DENSITY:	variable

WORD	PARAMETER
1	FLAG fixed to 7777.
2	DATE (731222.) = 22 DEC 73
3	TIME (24157.) = 02:41:57
4	SEC fixed to 1.
5	TAS (m/sec)
6	PRES(mb)
7	ALT(km)
8	TEMP (C)
9	Water content (gm/m^3)(Scatter Probe)
10	Water content (gm/m^3)(Cloud Probe)
11	Water content (gm/m^3)(Precip Probe)
12	Radar reflectivity (mm^6/m^3)(Scatter Probe)
13	Radar reflectivity (mm^6/m^3)(Cloud Probe)
14	Radar reflectivity (mm^6/m^3)(Precip Probe)
15	Total counts (Scatter Probe)
16	Total counts (Cloud Probe
17	Total counts (Precip Probe)
18	TWCI water content
19	TWCI freq1
20	Dewpoint (°C)
21	No. Density (SZD/m)(Scatter Probe)
22	No. Density (SZD/m)(Cloud Probe
23	No. Density (SZD/m)(Precip Probe)
24	TWCI freq2
25	TWCI temp1
26	TWCI temp2
27	largest particle size
28	average particle size
29	JW-LWC
30	particle type code
31-75	counts for size channels 1-45
76-120	unormalized Number Density for size classes 1-45 (SZD/m^3)
121-165	water content for size channels 1-45 (gm/m^3)
166-210	equivalent melted diamter for size channels 1-45 (u)

Appendix 18: Aeromet 210 Word Processed Data Tape



Appendix 18: TU-10 tape format with 'NEW' A-D buffer

IOT	A/C COMPUTER	LAB COMPUTER
6301	WAIT FOR GE INPUT	WAIT FOR TEKTRONIX INPUT
6306	READ GE INPUT	READ TEKTRONIX INPUT
6311	WAIT FOR GE OUTPUT	WAIT FOR TEKTRONIX OUTPUT
6316	SEND GE OUTPUT CHAR.	SEND TEKTRONIX OUTPUT CHAR.
6661		WAIT FOR CENTRONICS OUTPUT
6666		SEND CENTRONICS OUTPUT
6321	WAIT FOR TWCI INPUT	
6326	READ TWCI INPUT	
6341	WAIT FOR DOWNLINK OUTPUT	
6346	SEND DOWNLINK OUTPUT	
6144	READ INS DATA LOW ORDER	
6153	SKIP IF INS DATA READY	
6154	READ INS DATA HIGH ORDER	
6164	READ INS SIGN & ID	
6073	SKIP IF EVENT WORD READY	
6074	READ EVENT WORD	

Appendix 19A: RTX8 IOT's

IOT	Mnemonic	Description
6701	LWCR	Load word count register
6703	LCAR	Load current address register
6705	LCMR	Load command key register
6706	LFGR	Load function register and execute
6712	CLT	Clear transport's master registers
6714	RMSR	Read main status register
6716	RFSR	Read function register and status
6721	SKEF	Skip if error flag is on
6722	SKCB	Skip if controller not busy
6723	SKJD	Skip if job done
6724	SKTR	Skip if tape unit ready
6725	CLF	Clear controller and master

Appendix 19B: PDP8 Magnetic tape IOT's

Directive	Octal Code	Function
QIO	6001	queue an I/O request
EVENT	6002	declare an event
PEEK	6003	move exec core space to task area
POKE	6004	change a core location
RTRAP	6005	remove trap
SIEZE	6006	seize device
MARKT	6007	mark time
SYNC	6010	wait for event
ITRAP	6011	install trap
TRAPE	6012	exit from trap
RUN	6013	run task
ABORT	6014	abort task
ALUN	6015	assign logical unit to physical unit
TEVENT	6016	test event flag
CEVENT	6017	clear event flag
CHMSW	6020	change machine status word
DQUE	6021	remove user from Execute queue
FINT	6022	call floating point processor
SPREAD	6023	read switch register

Appendix 20: RTX/8 user directives

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2-8